APRIL, 1941

THE Petroleum Engineer

VOL. XII—NO. 7

THE PETROLEUM ENGINEER PUBLISHING CO. . . . Phone: Central-4571 . . . Seventh Floor Allen Building . . . DALLAS, TEXAS
Clarence Morris, President, 1929-40

A Magazine of Methods for Operating Men

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The Course of Oil

by K. C. SCLATER

Petroleum Industry Prepared

Petroleum's preparedness in the present national emergency is the beneficent result of progress, competition, and coöperation within the industry itself—and this despite inhibitions acquired in recent years because of threats of government control. Robert E. Wilson, petroleum consultant to the Office of Production Management on National Defense, in an address before the American Association of Petroleum Geologists assembled in Annual Convention at Houston, Texas, made pertinent reference to the enviable position of the petroleum industry of the United States in the present world crisis. His observations are worthy of emphasis.

"The outstanding development in the producing end of the industry since the last war has been the general adoption of proration policies designed to conserve the reservoir energy and insure greater ultimate recovery of oil from a given formation, and a more equitable division of this recovery among the different land owners. From the standpoint of its effect on petroleum supply, this operation is analogous to the building of dams on mountain streams to control the wasteful spring floods and insure a steady and continuing supply as it may be needed during the dry seasons. As a result of this policy of proration the producing branch of the petroleum industry is particularly well prepared for any emergency. During the last war the price of crude had to be increased very substantially in order to encourage more wildcatting and the drilling of many new wells. This, plus the general increase in the prices of products resulted in temporary profits for the industry, but it has not yet forgotten the headaches of the long morning after."

As for increasing production beyond present needs: "Today those states which have practiced sound conservation principles have built up tremendous underground reserves, available at a moment's notice for practically any emergency—and this without putting an extra load on the overburdened steel industry or the labor market to drill thousands of new wells."

Exploratory work to increase reserves must continue: "Of course, the industry must not relax its normal activity toward making new discoveries, although it should avoid unnecessary drilling and unsound well spacing programs which use up capital, labor, and steel to no useful purpose. New wells and fields must be discovered and connected up and new pipe lines built as old fields play out. All the producers ask is that they be given freedom of opportunity subject to the limitations of sound proration regulations, and they will see that every demand is met for years to come."

In regard to refining he pointed out that "Few, even in the industry, realize that the increase in our gasoline production has been about twelve-fold since 1916. Our unused refinery capacity of around 1,000,000 barrels daily is greater and more efficient than was our entire capacity in 1918. It would be possible, by rather moderate methods of reducing civilian consumption, to meet all military demands without any increase in refinery capacity, but the petroleum industry would not consider that it had done its duty by its country or its customers if this had to happen." So, "If we are to avoid such a possibility, the industry must at least keep its refineries expanding fast enough to keep pace with the growth of peacetime consumption and keep the customary reserve of 20 to 25 percent of shutdown capacity available for emergency wartime needs for which purpose it is more than adequate. As new and more efficient refining equipment is developed and installed, the old should, so far as possible, be held in reserve for emergencies."

Commenting on specific refinery products he had this to say regarding 100-octane gasoline: "This 100-octane fuel, which ten years ago was available only in laboratory quantities at a price of $10 per gallon, can now be made by any one of several newly developed synthetic methods, and is available in large quantities at around 17c per gallon f. o. b. refinery." Although the petroleum industry has already installed synthetic capacity equal to nearly twice the present domestic and foreign demand, "there is today substantial excess capacity available for the building up of a reserve for possible war demand. The present capacity is, however, barely enough to meet our probable peacetime requirements, including export, once our training program is fully under way" and not enough fully to meet present estimates of full wartime demand after our plane-building program is complete. Hence "the importance of building a stock pile now, while we do have some surplus capacity, seems obvious." And "while recently announced increases in capacity will cover all prospective demands for the next 15 to 18 months, we would like to see still more capacity built to take care of possible contingencies."

Pipe line facilities in all probability will have to be increased. "So far as the transportation of crude is concerned, there is adequate capacity in existing pipe lines to take care of any reasonable expansion, but it will, of course, be necessary to continue to build new lines into new fields and supplement lines into fields where the production is increased. If crude production had to be increased suddenly by increasing allowables in certain states, some new lines probably would be needed to get this crude to points where there was available refinery capacity. As a matter of fact, we are somewhat concerned by the fact that the great bulk of the readily available increase in crude supplies would have to come from points south of the Red River, while the spare refining capacity is widely scattered over the country."

There is no mistaking the petroleum industry's enviable position, and its readiness and ability to cope with all demands for oil and its products in any national emergency.

Highlights IN OILDOM

To Consider Spacing Plans

Four hearings are scheduled for April 21 before the Kansas Corporation Commission at Topeka.

Cities Service Oil Company and associates are seeking to have put into effect a plan for development of the Hall-Gurney and Lansing-Kansas City pools, of 14s-13w, in Russell County. According to the proposed plan, wells would be on a 10-acre basis but spaced in a triangular fashion to eliminate unnecessary drilling.

Cities Service and another group favor a similar plan for the Jordan pool, of 25s-14w, in Stafford County, and they also ask for permission to water-flood the Demel lease, in SW of 9-16s-13w, in the Susank pool of Barton County.

Gulf Oil Corporation and associates will present a spacing plan for NW of 6-18s-10w, in the Bloomer pool of Rice County.

Water-Flood Project for Lima Field

Wright Oil Company, according to Frank M. Wright, manager, is planning water-flooding a property in the old Lima field, Ohio. The project is on the J. G. Severns estate of 150 acres in Union Township, Mercer County, 20 miles west of Lima.

A secondary test well has been completed and reveals that the field can be repressured either with water or gas, Wright states.

Name Kansas Fields

The Kansas nomenclature committee of the Kansas Geological Society has approved the following names for new fields:

Kraft West for the area opened by Republic Natural Gas Company at its Radenburg No. 1, in CWL NW SE of 8-17s-11w, in Barton County, and given a state potential of 68 bbl. per day.

Catharine Southwest for the sector opened by Derby Oil Company at Miller No. 1 in CSL SW SW of 17-13s-17w, Ellis County, with a state potential of 185 bbl. per day.

Shaeffer for the district around the Atlantic Refining Company Shaeffer No. 1, in CWL NW SW of 3-21s-13w, which has been given a potential of 1175 bbl. per day.

Crude Oil Prices Advance

Within recent days crude oil prices have shown a rather general advance throughout the Mid-Continent, Illinois, Indiana, Michigan, and in some of the Rocky Mountain areas. In Illinois and Indiana the advance has been 7 cents a bbl.; in Oklahoma, Kansas, and Michigan, 5 cents; in Texas fields from 5 to 11 cents; New Mexico, a slight increase; North Louisiana and Arkansas, an advance of approximately 5 cents, and some Rocky Mountain areas were given about a 5-cent increase. Detailed prices can be found on page 14.

Oil Compact Commission Meets

The Interstate Oil Compact Commission held its quarterly meeting in New Orleans, Louisiana, on April 14. The Cole Committee, which is completing its investigation in Louisiana, attended the meeting. The Drafting Committee, Engineering Committee, and Regulatory Practices Committee of the Compact Commission made their reports, and an interesting and constructive program was held.

Oil Employees Entitled to Overtime

Employees of oil companies and pipe-line operators producing and transporting oil, which is sold in the same state to refineries or companies known to ship its products in interstate commerce, are covered under the Fair Labor Standards Act, according to the decision of Federal Judge James C. Wilson, for the Northern District of Texas, at Fort Worth. The decision was handed down in an employee suit, the case of R. F. St. John vs. H. H. Brown and others.

In his opinion, Judge Wilson held "to argue that these defendants as a group or organization, or individually, who pumped the oil and handled it, in a standardized way, to get it to market, were not producing goods for commerce, is equivalent to arguing that, a miner with his pick and lamp who goes down to the end of the shaft and there knocks or blasts the already uncovered coal out of its bed and shovels it into a push car to be conveyed to the surface, is not producing goods for commerce.

"The fact that the partnership here, owning and operating the leases and actually producing the oil, sold it, when so produced, to the co-partnership that gathered and transported it to market, however intrastate that transaction might be, does not affect the question . . . they must be held to know that which is of such common knowledge that the courts may take judicial knowledge of it, viz., that the greater percentage of all crude oil produced in Texas, certainly such as finds its way into major pipe lines, goes out of the state, though it may be in the form of by-products, for consumption . . . I hold that the law is applicable."

Judge Wilson also held that employees who are paid weekly or monthly salaries, even though the salaries exceed the minimum wage, are entitled to overtime compensation under Section 7 of the Act in addition to their salaries. This holding accords with the position of the Wage and Hour Division.

The case decided by Judge Wilson is similar to several others in the courts involving the production of "stripper wells" sold within the state of production.

U. S. Refining Capacity Ample

The United States has ample refinery capacity to take care of any expected increase in demand for petroleum products in 1941, the U. S. Bureau of Mines stated upon completion of its annual survey of domestic refinery capacity.

The total completed capacity of petroleum refineries in the United States, according to the U. S. Bureau of Mines report, increased 2 percent in 1940 (from 4,628,646 to 4,718,969 bbl. per day) as compared with the previous year; and the number of plants increased from 557 on January 1, 1940, to 562 on the first of this year.

The total capacity of operating cracked-gasoline units on the first of the year, the Bureau's survey revealed, likewise showed a gain, having increased almost 6 percent over the first of last year. Total capacity, on January 1, 1941, was more than 1,000,000 bbl. per day.

Low gasoline prices, competition for crude-oil supplies, particularly in Illinois, and the termination of a favorable distributing arrangement for independent plants in the Los Angeles area, the Bureau of Mines reported, forced the closing down of about 50 refineries during 1940. The number of operating plants accordingly declined from 461 on January 1, 1940, to 420 on January 1, 1941. These developments were also reflected in the capacity figures, the operating capacity declining from 4,196,694 bbl. per day on January 1, 1940, to 4,180,588 bbl. daily on January 1, 1941, and the inoperative capacity rising from 431,952 bbl. to 538,381 bbl. in the same period.

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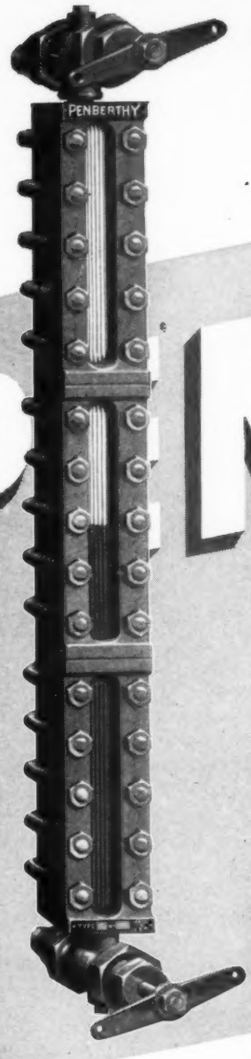

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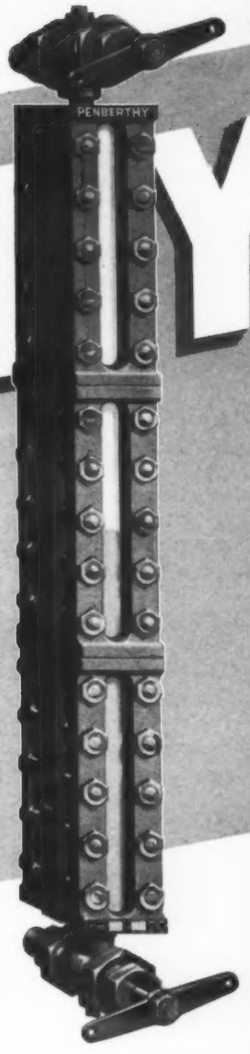

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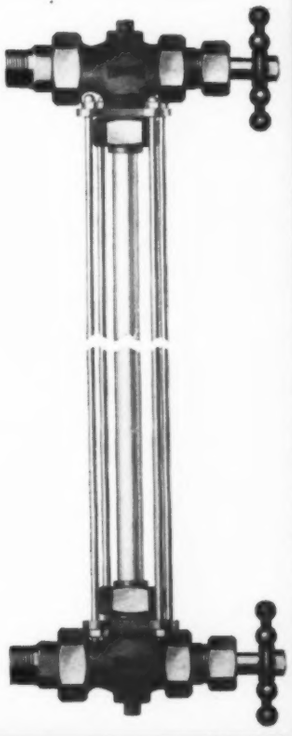

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PENBERTHY PRODUCTS

MAJOR *Pipe Line* ACTIVITIES

GLOBE Oil and Refining Company has asked for bids on a 225-mile gasoline pipe line from McPherson, Kansas, to Council Bluffs, Iowa, Frank L. Jehle, vice-president and general manager of the company, announces. The line will be laid of 6-in. pipe and construction is scheduled to begin in May.

The company, which has a refinery at McPherson, also plans to construct a 370,000-bbl. capacity gasoline terminal at Council Bluffs.

British American Oil Producing Company has asked permission of the United States' engineers office at Galveston, Texas, to lay a 4-in. line from its Tulsa No. 2 well, near Sabine, in Galveston County, to storage tanks. The well is located in the Gulf of Mexico from a point on the shore line about 7 miles southeast of Sabine, and is about 9000 ft. off-shore.

The Sinclair Refining Company has made application to the Pennsylvania Public Utility Commission for permission to lay a pipe line across Pennsylvania from Marcus Hook, where the company has a refinery, to the Pittsburgh area. The projected line would extend to Washington County, but whether it would be continued into Ohio is not known.

Other major companies that already have pipe lines from Marcus Hook to Pittsburgh, where they connect to lines into Oklahoma, Texas, and other oil-producing areas, include Standard, Gulf, Atlantic, and Sun.

The White Eagle Division of the Socony-Vacuum Oil Company, Inc., has awarded contracts for the laying of a gasoline and refined products line from Topeka, Kansas, to Sioux City, Iowa. The new line, which will connect with the company's gasoline trunk line extending from its refinery at Augusta, Kansas, to Kansas City, will consist of approximately 250 miles of 6-in. pipe. Work will begin about May 15 and the line completed in approximately 60 days.

Three contracts have been awarded:

Section 1, 58 miles, extending northeast from Topeka, to Midwestern Engineering and Construction Company.

Section 2, 91 miles, to Oklahoma Contracting Company.

Section 3, 90 miles terminating at Sioux City, Iowa, to Jones and Brooks, Inc.

Producing wells in the Hospital pool and Vogtsberger area, north Archer County, Texas, have received pipe-line facilities. Magnolia Pipe Line Company has laid a 4-in. line to the fields that connects with its 8-in. main line from the Ringgold field to the Hull-Silk field. Shell Oil Company's Coleman No. 1 well on block 74, A.T.N.C.L. survey and the Southern Exploitation Company's wells on L. F. Wilson land block 73, same survey, have been given connections by a pipe line consisting of 3- and 4-in. pipe.

United Gas Pipe Line Company has announced plans for laying a 49-mile line to extend from De Quincey, Louisiana, to Camp Polk near Leesville. It will consist of 20 miles of 10-in., 22 miles of 8-in., and 7 miles of 4-in. Gas will be taken from the Roanoke and South Jennings fields.

Natural Gas Pipeline Company of America has awarded contracts for the laying of two loops to its line, totaling 184 miles of 26-in. pipe. W. A. Bechtel Company will lay 83 miles from Osceola to a point near Muscatine, Iowa. O. E. Dempsey Construction Company has been given the contract for 101 miles to extend east of Crescent, Iowa.

It is possible that the United States government may act shortly to make possible the construction by the Plantation Pipe Line Company of a gasoline pipe line from Baton Rouge, Louisiana, to Greensboro, North Carolina, and possibly on to Norfolk, Virginia, according to the belief of well-informed sources. The proposed line would be 1261 miles long if laid only to Greensboro, and 225 miles longer if laid to Norfolk.

The project is a joint operation of Standard Oil Company of New Jersey, Standard Oil Company of Kentucky, and Shell Union Oil Corporation, under the corporate setup of Plantation Pipe Line Company.

Plantation has been actively engaged for a year attempting to obtain a right-of-way. It is understood that the only serious difficulty experienced has been with the railroads. Plantation applied to 24 railroads for permits to cross 81 rights-of-way. All but one of the applications were refused.

In Georgia, the legislature declined to grant the right of eminent domain to the pipe line to permit the oilmen to override the railroads' opposition, although President Roosevelt telegraphed Governor Talmadge a few hours before the senate voted, that gasoline lines were "essential" to national defense.

In Mississippi and Louisiana, Plantation has gone to court in an attempt to get a ruling that the right of eminent domain, which in those states applies to "oil and gas pipe lines," should be interpreted to include gasoline pipe lines.

In Alabama, "public carriers" under the law can cross railroads, and Plantation has to prove in that state that a pipe line is a public carrier.

In South Carolina, there is no law on the subject. In North Carolina, "local corporations" have the required right. Tennessee's laws give pipe lines eminent domain.

The government is interested in getting the pipe line laid for three reasons:

1. The establishment of an "interior line of supply" essential to defense.
2. The elimination of long ocean tanker hauls, so that such ships may be used strictly as navy auxiliaries.
3. A reduction in gasoline costs promised by the oil companies.

Secretary of the Navy Knox said in Atlanta on March 13 that construction of a line from Baton Rouge to Norfolk was vitally necessary.

He described the present ocean transportation of gasoline and fuel oil around Florida and up the coast as a "vulnerable point in our national defense" and said: "Such water transport in time of war would be in grave danger from submarine activity."

As the specifications for the pipe line now are drawn up, it could take 48,000 bbl. of gasoline per day from the Standard Oil Company of Louisiana refinery at Baton Rouge and the Shell Oil Company refinery at Norco, Louisiana.

This would be transported through 435 miles of 11-in. pipe, 399 miles of 9-in. pipe, 214 miles of 6-in., and 253 miles of 4-in.

Construction of 14 pumping stations is proposed. If the line were extended to Norfolk additional stations would be erected and the capacity of that part of the line increased to 72,000 bbl. per day.

Terminals would be provided at Meridan, Mississippi; Moundville, Birmingham, Montgomery, and Oxford, Alabama; Bremen, Columbus, Macon, Atlanta, and Athens, Georgia; Belton and Spartanburg, South Carolina; Charlotte, Salisbury, and Greensboro, North Carolina, and Chattanooga and Knoxville, Tennessee.

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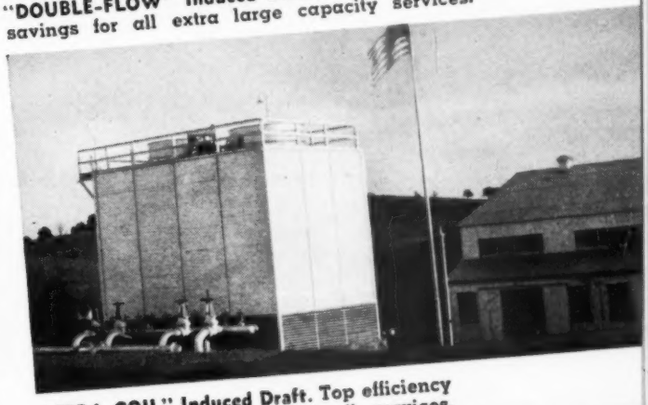

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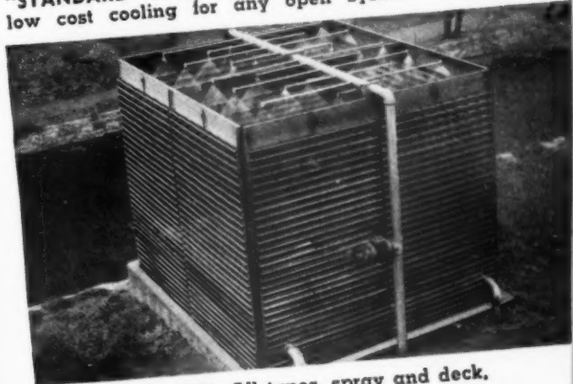

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MAJOR *Oil Field* ACTIVITIES

A NEW Hunton lime pool is believed to have been opened by Guy Scott and L. M. Griffith and their associates operating under the name of the National Petroleum Company, 12 miles northwest of Falls City, Richardson County, Nebraska. Their Lillian Oswald No. 1, in CNW SW of 15-2n-14e, found the lime at a depth of 2548 ft. and reported showings when cored to 2565 ft. If this proves to be a new pool it will be the fourth for Richardson County.

J. E. Crosbie, Inc., and William H. Elson prepared to make a drill-stem test after finding oil-saturated Wilcox sand from 4770-74 ft. in their Hogle No. 1, in SEC SW of 29-20-2e, northwest of Stillwater, Payne County, Oklahoma. Field men believe it may open another sizeable pool for Oklahoma.

Ownby No. 1 of Livermore, Inc., a Permian lime discovery 3 miles northeast of the Waples-Platter pool, southern Yoakum County, Texas, flowed 52 bbl. of oil in 3 hours through 2-in. tubing after being shut in 18 hours. Total depth of the well is 5348 ft.

The wildcat test of M. Spitler, W. H. Coats, and S. L. Hunter, in NE of 31-23-14, 1 mile west of New Madrid, New Madrid County, southeastern Missouri, has had a showing of oil at a depth of 1800 ft.

Naegel No. 1 of the Stanolind Oil and Gas Company, in CEL NE SW of 3-24-15w, 9 miles northwest of the Jordan pool, Stafford County, Kansas, is being regarded as the opener of a new pool. The hole filled 1600 ft. with oil in 30 minutes after the cement plug was drilled-out at a depth of 3828 ft. in the Lansing-Kansas City lime and the well swabbed at the rate of 30 bbl. per hour.

British American Oil Producing Company has successfully completed its State of Texas No. 2-71, 1¾ miles off the shore of Jefferson County in extreme southeastern Texas, and in the Gulf of Mexico. The well was drilled to a depth of 6721 ft. in the Miocene and plugged-back and tested through perforations from 4980-92 ft., the shallower of three producing zones found. On an unofficial test the well made 5.2 bbl. of 27-gravity oil per hour through ⅛-in. tubing choke. The discovery is an important one as it is the first well to be completed in the open Gulf and proves that vast oil reserves underlie the coast, according to W. K. Whiteford, executive vice-president and general manager of British American.

Derby Oil Company's Miller No. 1, in CSL SW SW of 17-13-17w, 2½ miles southwest of the Catherine pool, and 5 miles northeast of Hays, Ellis County, Kansas, apparently has discovered a new pool. The hole filled 775 ft. with 31-gravity oil in 5 hours after 8 ft. of Arbuckle lime was drilled from 3645 ft.

Hiawatha Oil Company (Benedum-Trees) has opened a new pool for White County, Illinois, with its Stinson No. 1 in SW SW NE of 19-7s-11e. From a total depth of 2129 ft. the well swabbed an estimated 20 bbl. of oil per hour.

AVERAGE CRUDE OIL PRICES

California	
Kettleman Hills	$1.04-1.19
Playa Del Rey	.65-1.08
Coalinga	.65-1.07
Wilmington	.60-1.14
Montana	.80-1.15
Wyoming	.35-1.30
Colorado	.92- .98
New Mexico	.77-1.02
Texas	
North Central	.78-1.08
Panhandle	.60-1.02
West Texas	.60-1.02
Gulf Coast	.96-1.38
Darst Creek	1.04
East Texas	1.15
Talco	.72
Kansas	.65-1.15
Oklahoma	.65-1.15
Arkansas	.58-1.10
Louisiana	
Gulf Coast	.96-1.38
North Louisiana	.78-1.10
Illinois	1.05-1.22
Kentucky	1.05-1.20
Indiana	1.05-1.15
Ohio	
Lima	1.05
Michigan	1.07-1.27
Pennsylvania	
Bradford	2.30
Southwest	1.95
Eureka	1.89
Buckeye	1.55
Corning	1.17
Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]B. of M. Calculated Requirements (March)	Week Ended March 29, 1941	Week Ended March 1, 1941	Week Ended March 30, 1940
Oklahoma	437,400	[2]408,450	413,250	402,050
Kansas	194,200	[2]211,650	202,550	180,400
Nebraska	3,200	[2] 4,350	4,300	
Panhandle Texas		77,450	68,050	82,200
North Texas		101,650	101,100	104,600
West Central Texas		30,600	30,200	33,900
West Texas		241,400	236,100	276,650
East Central Texas		77,900	73,200	91,150
East Texas		445,000	374,600	396,900
Southwest Texas		210,200	205,350	270,350
Coastal Texas		257,100	256,400	255,050
TOTAL TEXAS	1,327,400	1,441,300	1,345,000	1,510,800
North Louisiana		70,800	70,050	68,800
Coastal Louisiana		235,250	222,300	212,900
TOTAL LA.	291,300	306,050	292,350	281,700
Arkansas	69,700	70,950	70,550	69,000
Mississippi	20,300	[2] 17,750	20,400	7,850
Illinois	335,200	325,200	331,150	426,950
Indiana	22,600	[2] 19,850	20,900	8,500
Eastern (not incl. Ill. & Ind.)	96,500	93,200	94,300	96,300
Michigan	47,700	37,900	40,200	64,300
Wyoming	83,900	74,350	81,050	68,750
Montana	21,900	18,200	18,050	17,000
Colorado	3,900	3,850	3,700	3,900
New Mexico	103,900	109,000	104,200	112,550
TOTAL EAST OF CALIF.	3,059,100	3,142,050	3,042,350	3,250,050
California	596,400	604,500	589,900	591,200
TOTAL U. S.	3,655,500	3,746,550	3,632,250	3,841,250

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of March. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 a. m. March 26.

MUD ACID SERVICE

Another Application of Chemistry

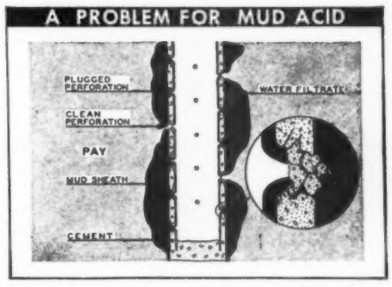
Dowell Provides an Answer to an Old and Difficult Production Problem

Mud Acid Service is solving the problem of increasing production from sand wells. It dissolves bentonite and clay from the formation and disintegrates the mud sheath that may cover the producing section. The results of Mud Acid Service indicate that a new era is at hand in low cost completing and reconditioning of oil, gas and input wells.

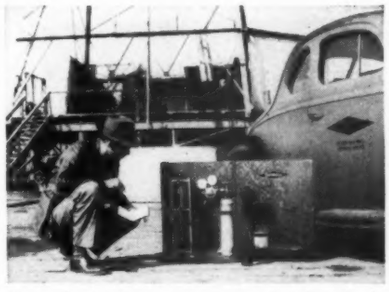
In addition to increasing the production from new wells, Dowell's new chemical treatment applies with good results to old wells that have been producing for years. The same conditions often exist in old wells as in new. By removing mud or clay from the pay formation, from screen openings or by removing trapped mud fluids, production can be substantially increased. In several instances, old wells that have declined to the pumping or gas lift stage have been made to flow with substantial increases in production.

In Mud Acid Service the treating solutions have stabilized low surface tension, high wettability and emulsion preventing properties. Because of these characteristics, better penetration, lower treating pressure and easier cleaning of the well result.

Special literature on the Mud Acid Service is available on request. Telephone your local Dowell representative or write: DOWELL INCORPORATED—Kennedy Building, Tulsa, Okla.



After casing perforation jobs, shattered cement fragments often keystone around the bullet holes hindering full production. Pay zones clogged with drilling fluid and native elements may be passed up when drilling to deeper horizons. Mud Acid treatments clear the perforations and pore passages, thereby increasing production.



Special testing equipment developed by Dowell is employed on location, to determine the solubility of the mud. From data thus gathered, the relative solubility of any mud in Mud Acid is determined.

RESULTS OF RECENT MUD ACID TREATMENTS

WELL No.	POOL	LOCATION	FORMATION	THICKNESS AND DEPTH OF PAY	REASON FOR MUD ACID	GALLONS OF MUD ACID	PRODUCTION BEFORE TREATMENT	RESULTS AFTER TREATMENT	OUTSTANDING FACTORS OF TREATMENTS
1	UNIVERSITY	E. BATON ROUGE PARISH, LOUISIANA	MIOCENE SAND	7 FT. AT 6411 FT.	CLEAN CEMENT, SILT, AND MUD DAM FROM PAY SECTION	1000	DRY HOLE	65 TO 70 BBLS./DAY	TUBING SWABBED TO 5500 FT. BEFORE FLUID ENTERED WELL. SETTING OVER NIGHT WELL FILLED TO 1700 FT. LEVEL. THREE RUNS WITH SWAB AND WELL BEGAN TO FLOW SHORTLY AFTERWARD.
2	OLD OCEAN	BRAZORIA COUNTY, TEXAS	OLIGOCENE (FRIO)	165 FT. AT 9760 FT.	CLEAN GUN PERFORATIONS	3000	30,000,000 CU. FT./DAY INPUT AT 3800 LBS./SQ. IN.	65,000,000 CU. FT./DAY INPUT AT 3250 LBS./SQ. IN.	TO REMOVE ALL OILS IN AND ON SAND 23 BBLS. DISTILLATE WERE USED. APPROXIMATELY 10 BBLS. WERE SQUEEZED INTO FORMATION. REMAINDER USED TO WASH PAY FACE.
3	VILLE PLATTE	EVANGELINE PARISH, LOUISIANA	SPARTA (HAAS)	27 FT. AT 8944 FT.	CLEAN CASING PERFORATIONS	1000	3,000,000 CU. FT./DAY INPUT AT 3600 LBS./SQ. IN.	10,000,000 CU. FT./DAY INPUT AT 2800 LBS./SQ. IN.	ORDINARILY, INPUT PRESSURES IN THIS FIELD RANGE BETWEEN 3000 to 3600 LBS./SQ. IN. BEFORE MUD ACID TREATMENTS ARE MADE.
4	LANCE CREEK	NIOBRARA COUNTY, WYOMING	LEO	25 FT. AT 5020 FT.	CLEAN GUN PERFORATIONS AND REMOVE MUD FROM BEHIND CASING	1000	DRY HOLE	1440 BBLS./DAY	THE MUD ACID WAS FORCED INTO THIS FORMATION SLOWLY AT FIRST UNDER 1200 LBS./SQ. IN. PRESSURE UNTIL LATE IN THE TREATMENT WHEN PRESSURE "BROKE" TO 500 LBS./SQ. IN.
5	BARBER'S HILL	CHAMBERS COUNTY, TEXAS	MIOCENE	91 FT. AT 2347 FT.	DEMUD FORMATION AND CLEAN SCREEN	1250	PUMPED 10 BBLS./DAY	FLOWED AT RATE OF 10 BBLS./HOUR	WHEN THIS WELL WAS DRILLED, A BLOWOUT WAS PREVENTED AND MUCH MUD WAS LOST INTO THE PAY SAND. WELLS OF THIS TYPE REQUIRE GREAT CARE IN ACIDIZING. THIS WELL WAS TREATED IN TWO STAGES.

Look to DOWELL
FOR OIL AND GAS WELL CHEMICAL SERVICE

DOWELL INCORPORATED
Executive Office: Midland, Mich.
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KENNEDY BLDG., TULSA, OKLA.
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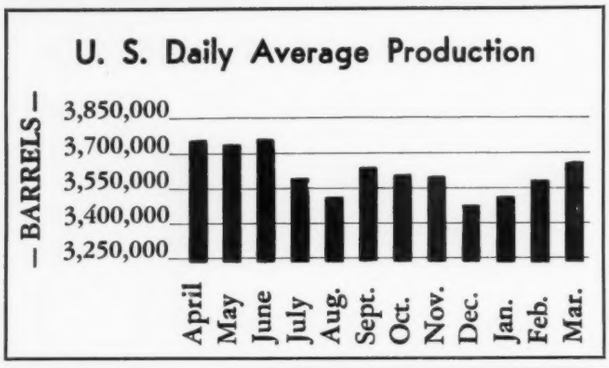
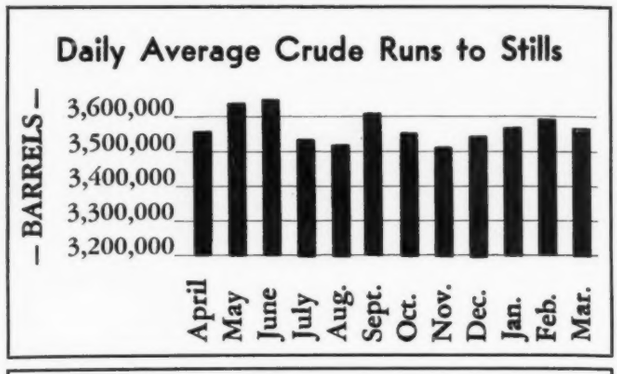
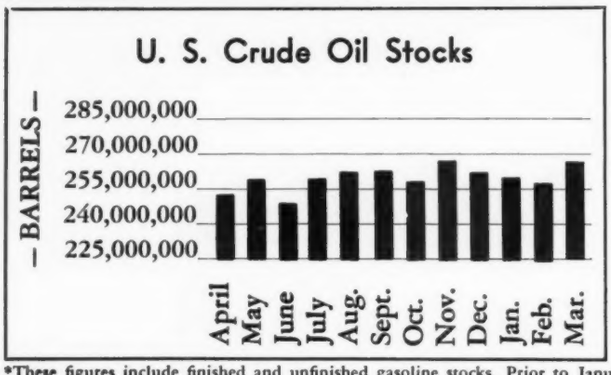
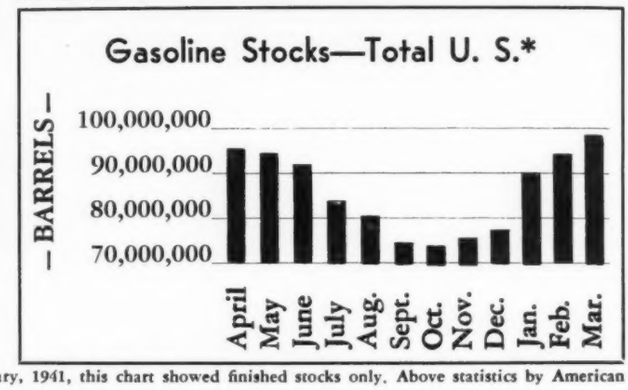
The Dow Chemical Company

PETROLEUM *Statistics* AND FIELD *Operations*









*These figures include finished and unfinished gasoline stocks. Prior to January, 1941, this chart showed finished stocks only. Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for March, 1941

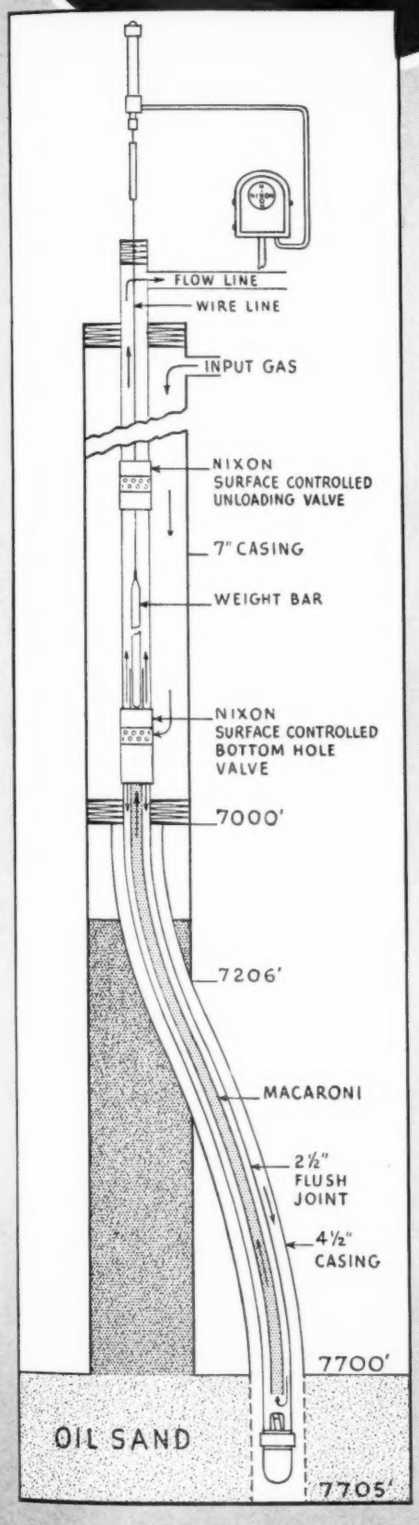
Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	59	56	8	31	3500-3700	2	40	Rotary
Duval County	23	14	3	13	1554-2900	2	22	Rotary
Ector County	26	25	13	40	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	40	37	20	74	1700-3900	2	40	Rotary
Nueces County	25	20	3	9	3922-5878	2 or 3	21-54	Rotary
K.M.A. Field	17	16	7	26	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	6	6	2	6	4495-4912	2	19-29	Rotary
OKLAHOMA								
Fitts Pool	4	2	1	3	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	21	17	3	14	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	27	23	7	20	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	11	9	14	25	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	288	216	281	114	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	13	13	8	27	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	2	2	1	8	8300-8730	3 or 4	40	Rotary
Wilmington	13	13	9	9	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for March, 1941

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1940 (In Barrels)
	March	February	March	February	March	February	March	February	March	February	
Arkansas	13	10	7	6	8	13	2	1	20	24	25,699,000
California	89	81	80	72	90	114	57	86	139	152	224,029,629
Colorado	1	2	1	2	....	....	1	2	33	36	1,369,788
Illinois	288	198	216	141	392	297	281	266	114	102	146,572,938
Indiana	38	27	26	17	....	....	6	7	56	59	4,946,384
Kansas	156	147	120	114	152	186	33	32	213	212	65,602,452
Kentucky	13	23	3	7	....	....	9	10	90	92	5,282,335
Louisiana	96	114	74	84	148	149	39	34	274	232	103,738,728
Michigan	68	66	27	28	72	76	37	38	145	143	19,768,984
Mississippi	18	11	15	9	....	....	2	3	21	24	4,313,159
Montana	14	14	12	12	....	....	4	3	66	67	6,663,872
Nebraska	2	6	0	2	5	11	2	3	19	23	267,553
New Mexico	33	21	26	17	44	38	19	16	121	116	38,893,898
New York	57*	52*	57*	52*	....	....	9	10	66	64	4,240,441
Ohio	97	110	84	84	....	....	45	44	167	161	3,132,280
Oklahoma	148	121	113	87	152	186	41	43	260	263	152,516,049
Pennsylvania	179*	158*	169*	150*	....	....	....	....	....	....	17,987,217
Texas	778	700	581	533	1235	1062	514	404	1557	1227	490,101,261
West Virginia	41	49	35	36	....	....	23	20	151	160	3,586,653
Wyoming	6	5	5	5	....	....	10	9	60	63	25,863,538
Total	2135	1915	1651	1458	2208	2132	1134	1031	3572	3220	1,344,576,159

*Includes water-intake and pressure wells.

GAS PUMPING WITHOUT MOVING PARTS IN CROOKED HOLE



A TYPICAL EXAMPLE OF NIXON GAS-LIFT ADAPTABILITY!

Crooked holes have always been the meanest kind of production problem. But when you add low pressure and a thin sand section you have an economic impossibility.

A Gulf Coast operator with just such a job came to Nixon for help. His well had been plugged back from 7705' thru 7" casing then whip-stocked and drilled to its original depth where there is a 5-foot, low-pressure sand. Four and one-half inch casing was set in the side-tracked hole. He had tried an open type gas-lift without success, as operating gas pressure held back oil production.

Could we solve his problem and make production profitable? Nixon Gas-Lift engineers immediately went to work. They planned a Nixon closed-intermittent surface control Gas-Lift installation, that is producing this well *without a moving part in the Crooked Hole*. A hook wall packer was set at 7000', and 700 feet of 2½" flush joint tubing extended to the bottom. A Nixon Bottom Hole operating valve was installed above the packer and macaroni tubing run to a point just above the bottom hole standing valve.

By intermitting Gas pressure thru the Operating Valve into the annulus between 2½" flush joint tubing and macaroni string, production is forced up through the macaroni string into main tubing to surface.

This Nixon installation has been operating for six months. Production has gradually increased — operating cost continually decreased until what was a losing well is now profitable.

Nixon's development of Surface Control Gas-Lifting is solving scores of such seemingly impossible production problems. A Nixon Engineer can plan an installation of the Nixon System that will efficiently and profitably produce your wells.

Wilson Supply Co.

1412 Maury St., Houston, Texas

MAJOR *Refining* ACTIVITIES

Percent Refining Capacity Operated

Western Division, 77.7 Percent **Central Division, 82.1 Percent** **Eastern Division, 91.5 Percent**

BY DECREE of the French High Commission published on December 27, 1940, the new petroleum refinery at Tripoli, Lebanon, was organized under the supervision and control of the High Commission as a special entity enjoying budgetary autonomy, self-administering and with the power to effect directly its own financial operations, although it will be operated under an appropriation from the government budget, announces American Vice Consul William Whitman, II, at Beirut.

This refinery has begun operating on stocks of crude oil stored at Tripoli, one of the terminals of the Iraq pipe line.

A bill is now being considered by the Danish Parliament, which, if it is passed, will authorize the expenditure of 15,000,000 kronor ($3,000,000) for the construction of a refinery to be under the direction of the government. The possibilities for the establishment of a refinery of this type have been considered for several years, but in the earlier stages the proposals were made by large private interests who were to have the control, says a report from American Commercial Attache Julian B. Foster at Copenhagen.

In the report of the commission that has been investigating this project it is pointed out that when the erection of a Danish refinery was first considered the fear was expressed that it would be entirely dependent on the larger oil companies, as it was presumed that they controlled the majority of the crude oil production. Subsequent events made it known, however, that the four largest companies controlled less than half the world's crude oil production, the remainder being divided between a very large number of smaller companies. The commission appears to feel that it should not be difficult for a Danish refinery to supply the Danish market with almost all types of products. Members of the Commission estimate that a reasonable capacity for a Danish refinery would be about 2,450,000 bbl. of oil per year. Such a plant would care for approximately one-third of the Danish consumption.

When expansion of its refinery at Fort Worth, Texas, is completed, Magnolia Petroleum Company will close its refinery at Corsicana, Texas, probably by the middle of the year, it has been announced by D. A. Little, president of the company. The refinery at Corsicana was the first plant constructed west of the Mississippi River.

Rock Island Refining Corporation is constructing its 6000-bbl. refinery at Zionsville, Indiana, 15 miles northwest of Indianapolis, which is expected to be completed by September 1. The company is an affiliate of the Rock Island Refining Company, which operates a 7500-bbl. refinery at Duncan, Oklahoma.

Arkansas Louisiana Gas Company is installing a blending unit at its natural gasoline plant in the Waskom field, Harrison County, Texas. The gasoline plant has been in operation two years.

The second carbon black plant for South Texas has been placed in operation by the United Carbon Company near the McCampbell field. Existing units were erected at a cost of approximately $500,000 and another $300,000 is expected to be spent for additional units in the future.

Pure Oil Company is actively engaged in installing an aviation gasoline unit at its Toledo, Ohio, refinery. The new unit will have a capacity of approximately 3000 bbl. of motor fuel per day.

The Texas Company has applied for a permit to operate an experimental gas-oil condensate recovery plant in the Paradis field of St. Charles Parish, Louisiana. The proposed plant would process 5,000,000 cu. ft. of gas per day and recover an estimated 125 bbl. of fuel. Continental Oil Company operates similar plants in the Ville Platte and Tepetate fields.

The Southwest Oil and Refining Company has been formed by A. R. Matthews of St. Elmo, Illinois, and associates, and purchased the Tyreco Refinery at Artesia, New Mexico. The purchase was from Bethlehem Supply Company and Black, Sivalls and Bryson, who foreclosed on the property last year. The existing plant has a capacity of 2000 bbl. per day and the new owners plan to add a 1600-bbl. cracking unit.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended March 29, 1941
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	595	92.5	20,495	16,871
Appalachian	91.0	134	94.4	3,231	854
Ind., Ill., Ky.	90.2	586	87.5	19,818	5,338
Okla., Kans., Mo.	76.9	282	87.3	8,941	3,143
Inland Texas	59.6	103	61.7	2,282	1,754
Texas Gulf	89.2	848	88.8	15,526	12,292
Louisiana Gulf	97.6	122	76.3	3,429	3,348
No. La. and Ark.	51.5	50	96.2	580	858
Rocky Mountain	56.0	58	85.3	1,740	649
California	87.3	512	70.1	16,635	78,824
Reported	86.2	3,290	84.1	92,677	123,931
Estimated Unreported		335		7,050	2,170
*EST'D TOTAL U. S. MAR. 29, 1941		3,625		(a) 99,727	126,101
*EST'D TOTAL U. S. MAR. 22, 1941		3,655		99,541	126,184
U. S. B. of M. *MARCH 29, 1940		**3,551		103,283	126,106

*Estimated U. S. Bureau of Mines' basis.
**March, 1940, daily average.
(a) Finished, 92,428,000 bbl.; unfinished, 7,299,000 bbl.

THE Petroleum Engineer

APRIL, 1941

Practical Suggestions For Increasing Utility of Oil Storage Tanks

Exclusive

☆ Seven relatively inexpensive alterations in practice are outlined that merit consideration by all tank owners

by Harold H. Yackey

STORAGE tanks are without question one of the most important classes of oil-industry equipment. Important because they directly affect practically every oil-industry consideration: investment in both facilities and products, direct and indirect operating and maintenance costs, taxes, insurance, earthquake and fire protection, sabotage, and public relations.

With the exception of the well itself, the oil tank is the most permanently placed type of oil-industry equipment. It is seldom economical to move a large storage tank. This very permanence should demand extreme care in the decision to build new storage. All existing storage should be carefully scrutinized periodically for justification of its existence and when it is no longer justified it should be removed. Tankage should be periodically evaluated according to the actual usage demand and the cost of all major repairs should be compared to tank value before repairs are made.

The argument used to be advanced that the storage of oil in tremendous volumes was necessary because oil was the industry's stock in trade. Fifteen or twenty years ago the hoarding of oil was considered desirable because of the then ever-considered possibility of oil shortage and because of speculation in price change. Sabotage considerations alone make unnecessary storage unpopular today, and as to speculation value, the writer knows of one 80,000-bbl. tank containing oil that hasn't moved in more than 30 years.

The purpose of this article is to offer suggestions for improving the use of oil storage.

Dead storage has been condemned above and is not considered further. Seasonal storage, whether the holding of heavy fuels during the summer months against winter usage and the holding of refined stocks during the winter against summer usage, or the use of tanks to store seven-day receipts against five-day pumping, is considered operating storage.

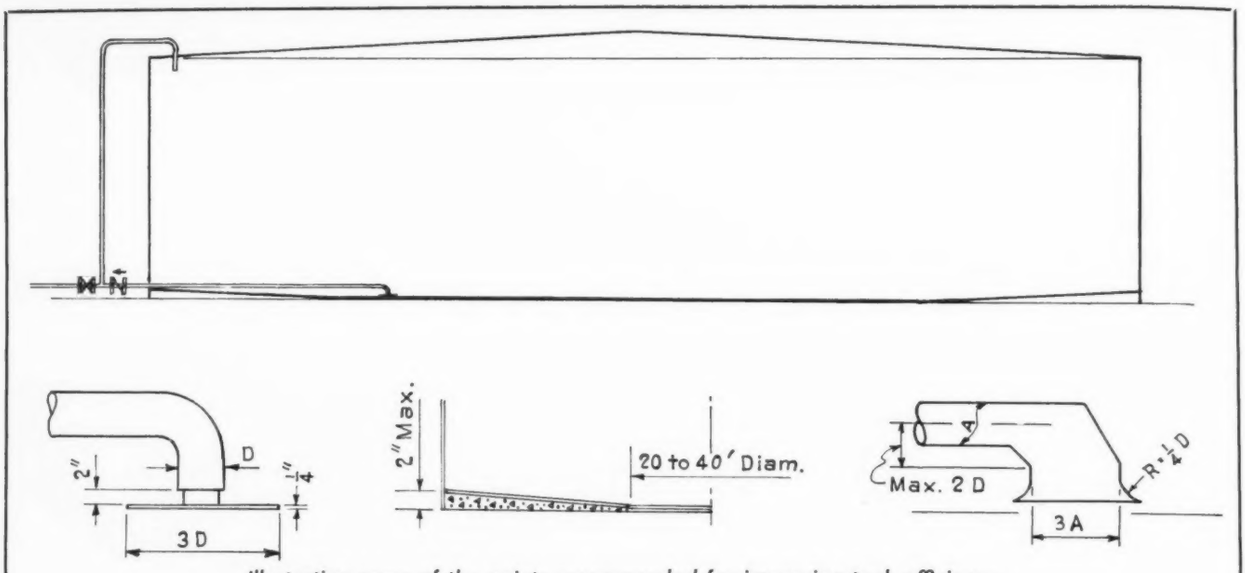
The improvements described herein will:

1. Increase the usable capacity of the tank by eliminating bottom space wastage.

2. Increase the utility of the tank by permitting immediate change-over from one to another type of petroleum product.

HAROLD H. YACKEY

from 1928 until December, 1940, was in the employ of the Union Oil Company of California —From 1932 until that date he had been assistant superintendent of pipe lines for the company—He resigned to take a position as industrial engineer with the Lockheed Aircraft Corporation, Burbank, California—Has a degree in mechanical engineering from the University of Illinois.



Illustrating some of the points recommended for improving tank efficiency

3. Eliminate tank cleaning operations to get rid of bottom sediment, wax, and water emulsions.

4. Reduce to an insignificant amount tank bottom repairs.

5. Reduce the intake friction losses of the swing pipe on high velocity flow tank connections.

6. Make use of the safety advantage of the surge tank without regularly keeping it in operation.

7. Eliminate the expense of gauging by personal attendance (which often means a man 24 hr. a day).

The above items are discussed as follows:

1. By equipping the end of the suction pipe, whether at shell or on swing pipes with downturned ends extended to the desired level, the oil level can be lowered to as little as 2 in. This is in actual practice on 55,000- and 80,000-bbl. tanks in ship loading service. When a predetermined minimum level is desired to be maintained, for instance, 3 in. of water over oil-soluble-coated or leaky bottom, a ¼-in. thick round plate 3 pipe diameters across is spaced off the pipe end 2 in. and the bottom position of the plate limited with blocks.

2. With a maximum of 2 in. of oil remaining in the bottom the contamination from one type of crude to another is practically negligible. With the shape of tank bottom discussed under (4) the amount of oil is actually negligible.

3. When the tank is repeatedly pulled down to a nearly dry bottom there is no opportunity for bottom sediment, wax, or water emulsions to accumulate. If the tank is left static long enough for this separation to occur, the first oil removed will include these undesirables. They are forced to suction by the pressure head of the full tank and can be transferred to a separation tank or to other working equipment very easily.

4. The tank bottom shown is not flat but is graded toward a center area from 20 to 40 ft. in diameter. At the shell in a 120-ft. diameter tank on good foundation the bottom need not be more than 12 in. above grade level. The space from bottom to grade if filled with non-corrosive rock or other material will greatly reduce corrosion from underneath. The sloping bottom drains the water inside the tank to the center area where it will not affect a large area, even if it is allowed to accumulate and corrode the bottom plates. One large oil company now recognizes the need for grading the tank bottom but does it by sloping outward rather than inward.

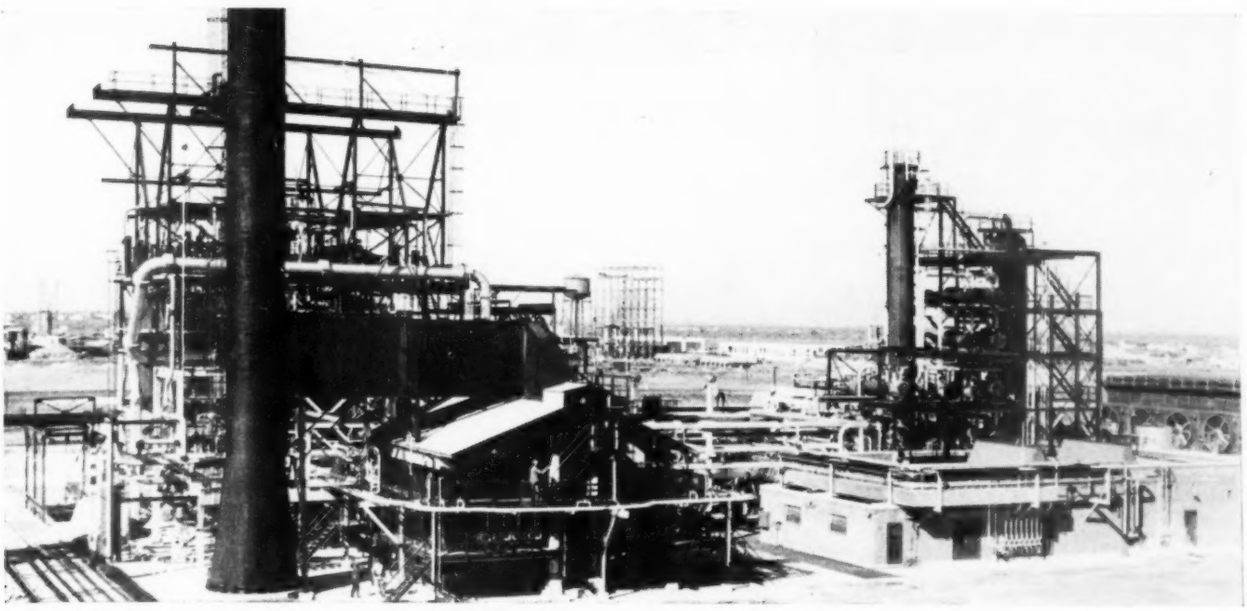
5. The flaring and rolling of the edges of the outlet pipe end reduces very decidedly the friction loss due to turbulence that is encountered with straight ends. It has been found that the gradual enlargement of the end to three times of the pipe cross-sectional area in not more than 2 diameters of distance from the center of the pipe is sufficient. Best rolling of edges is with radius of flare not less than one-fourth the diameter of pipe.

6. Tanks are still used for surge purposes on booster station main-line pumps to avoid the use of pressure-relief valves. Many modern stations have pumps automatically controlled by suction pressure, but accidental shutdown of pump still necessitates surge tank use. To offer this protection and still permit full tank height control conditions with empty tank safety and permit the use of tank interchangeably with various crudes, the described overshot connection has been used in several locations.

The check valve to the tank normally remains closed and pumps operate on fluid level in the riser. This gives maximum pressure variation for minimum oil volume change and makes pump controls very sensitive to line conditions. Should the pump shutdown for any reason, the incoming oil flows into tank. When it is desired to pump-out tank, the pump is hand controlled to pump faster than oil is received from preceding station and oil is taken from tank.

7. In many locations an extra man is maintained on every tour or shift of a crew because of the necessity for periodically gauging the level of oil in storage tanks that are situated far from the rest of the station. When the writer left the oil industry he was working on this problem with a certain equipment manufacturing company who now have ready for test an electrically indicating automatic remote reading tank gauge that will read to one-eighth of an inch. This device should soon be available for use anywhere. Its advantages are immediately apparent.

The first six of the above suggestions are easily applied, add practically nothing to tank cost, and help to make tanks more useful, less troublesome, and more efficient. They were all developed by discussions, trial and error, and were first used after overcoming the usual great amount of reactionary conservatism encountered in similar developments. It is hoped that those who have tank problems will try them out and when convinced of their value pass the ideas along to others who may profit thereby.



Hydroforming unit of Pan American Refining Corporation at Texas City, Texas

Hydroforming Is New Dehydrogenation Process

☆ First commercial plant reforms 7500 bbl. of 40-45 octane naphtha to high-octane (80 A.S.T.M.) product

D. J. Smith, Vice-President and General Manager
and
L. W. Moore, Technical Assistant, Pan American Refining Corporation

ALTHOUGH the use of catalysts to promote chemical reactions dates back almost to the beginning of chemical knowledge, it is only in the last five years that catalytic petroleum refining processes have found a wide commercial application in the United States. The most recent addition to this growing family is the hydroforming process, so named because it is a catalytic process for the "reforming" or converting of low-octane to high-octane gasolines at high temperatures in the presence of hydrogen gas.

The first commercial hydroforming plant was placed in operation recently at the Texas City, Texas, refinery of the Pan American Refining Corporation. It is capable of reforming about 7500 bbl. per day of 40 to 45 octane heavy naphtha to an 80 percent yield of about 80 A.S.T.M. octane gasoline. The unit is designed to take all the low octane heavy naphtha produced from the two largest cracking units in the world (capacity about 40,000 bbl. per stream day each) in addition to small amounts of heavy naphtha produced from miscellaneous crude topping operations. The product from the Texas City plant will be blended into the principal grades of gasoline marketed by the American Oil Co.

Nature of Process

Inasmuch as the hydroforming process involves carrying on a reaction in the presence of hydrogen, it might appear that this process is closely related to the hydrogenation process. This is not the case, however. Hydrogenation reactions involve the addition of hydrogen to hydrocarbon molecules, whereas the net effect of the hydroforming process is to dehydrogenate, that is, to take hydrogen away from hydrocarbon molecules. Part of the hydrogen thus produced is recirculated with the fresh feed to control the rate and extent of the dehydrogenation reaction. The most important property of the hydroforming catalyst is that it causes ring-closure to occur along with dehydrogenation, so that the product contains a high percentage of aromatic hydrocarbons and only a small quantity of aliphatic unsaturates. Consequently, the product is unusually stable, and, in the case of the Texas City plant, is blended directly into finished gasoline.

Although the design of the Texas City plant presented some difficult engineering problems, the process flow is relatively simple. The fresh feed, con-

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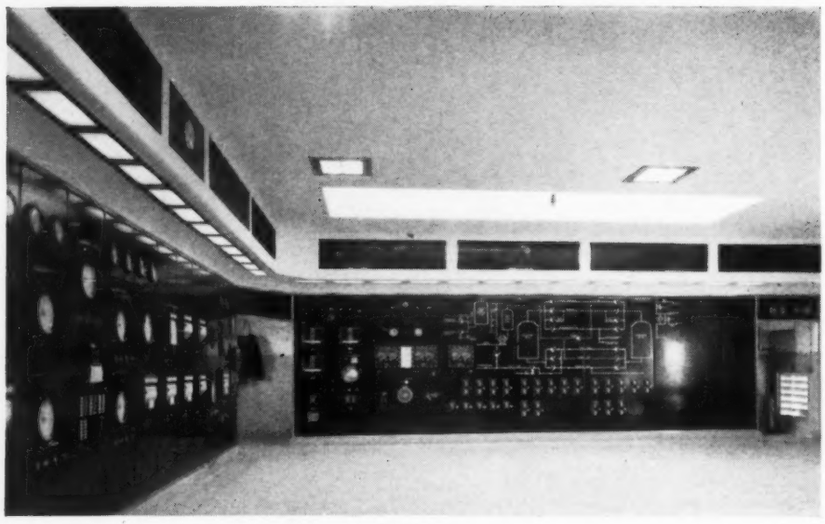
was born in Illinois—Was graduated with a B.S. degree from the Electrical Engineering School of the University of Illinois in 1914—Leaving college, he spent two years in sales engineering and on April 15, 1916, received an appointment from the Standard Oil Company of Indiana to their engineering department at the Whiting Refinery—In 1916 this company sent him to Oklahoma as superintendent in charge of construction on its casinghead plants—In 1920, Smith was made chief engineer at Caspar, Wyoming—In October, 1927, he received the appointment as assistant general manager of the Pan American Refining Corporation and was placed in charge of construction and operation of the Aruba Refinery where he remained until April, 1932—Since 1932 he has been the vice-president and general manager in charge of manufacture for the Pan American Refining Corporation.



Control board for hydroforming unit

sisting of a 40 to 45 octane heavy naphtha, is preheated by heat exchange with hot reaction products and sent to a combination naphtha and recycle gas preheater furnace. A hydrogen-rich recycle gas stream from a gas separator is also preheated by heat exchange and sent through a separate coil in the preheater furnace and heated to a high temperature. The two streams issuing from the furnace are then mixed and sent to the catalytic reactors, which are under substantial pressure.

The hot reaction products leaving the catalytic reactors are partly cooled by heat exchange with cold naphtha feed and other products. They are then cooled to normal temperature and sent to a gas separator. Part of the gas from the separator is used as recycle gas, and the rest goes to the refinery fuel system. The liquid from the gas separator is pumped to a stabilizer tower where the last traces of gas are removed, and then to a rerun tower where a small amount of heavy polymer is removed. The product from the rerun tower is sent to storage from which it is blended into finished gasoline.

During the course of the hydroforming reaction, a small amount of coke is deposited on the catalyst. As the amount of coke deposited increases, the activity of the catalyst gradually decreases so that it is necessary to remove a catalytic reactor from service periodically and burn the coke off in order to restore catalyst activity. Burning is done by recirculating flue gas through the reactors, the rate of burning being controlled by adding small amounts of air to the flue gas. Reactivity is carried out at high pressure and carefully controlled temperatures.

Engineering Features

The Texas City plant has two large catalytic reactors, which are in service alternately, one being on stream and one off for reactivation at all times.

In designing the plant, care was taken to avoid thermal cracking of the naphtha before it contacts the catalyst. Thermal cracking of the naphtha is undesirable because it decreases both the yield and octane and results in excessive coke deposition.

The design of the recycle gas stream and reactivation systems was complicated from an economic standpoint, because, for any given octane level, coke deposition is a function of the amount of recycle gas and the hydrogen concentration of the recycle gas, and consequently the size of the reactivation system is dependent on the size of the recycle gas system. This problem, in addition to many others in connection with the design, was made more difficult by the fact that the process development did not go through the usual stages of pilot plant to semi-commercial to full-scale design. Virtually all data used in the design had to be obtained from laboratory operation.

Operation of the reactivation system is entirely automatic and is controlled through a time-cycle mechanism. Because of the relatively long reactivation and on-stream periods, the time-cycle mechanism is also used to change conditions in fractionating towers to take care of variations in product take care of variations in product quality with change in catalyst activity.

The hydroforming process, as installed, is a development of the research organizations of several companies, including, primarily, the M. W. Kellogg Company, Standard Oil Development Company, and Standard Oil Company (Indiana). The design of the Texas City plant was made by engineers of the M. W. Kellogg Company in collaboration with engineers of the Pan American Refining Corporation and Standard Oil Company (Indiana). Construction work was done by M. W. Kellogg Company. The unit is being operated under patent license from the Standard Catalytic Company, which has important patent rights for this and related processes.

Yields and Product Quality

Although the hydroforming process is sufficiently flexible to produce gasolines over a wide range of octane numbers as high as 90 A.S.T.M., the conditions selected for the design of the Texas City plant were those that produce 80 percent of an 80 A.S.T.M. octane number gasoline. Typical charge and product inspections are as follows:

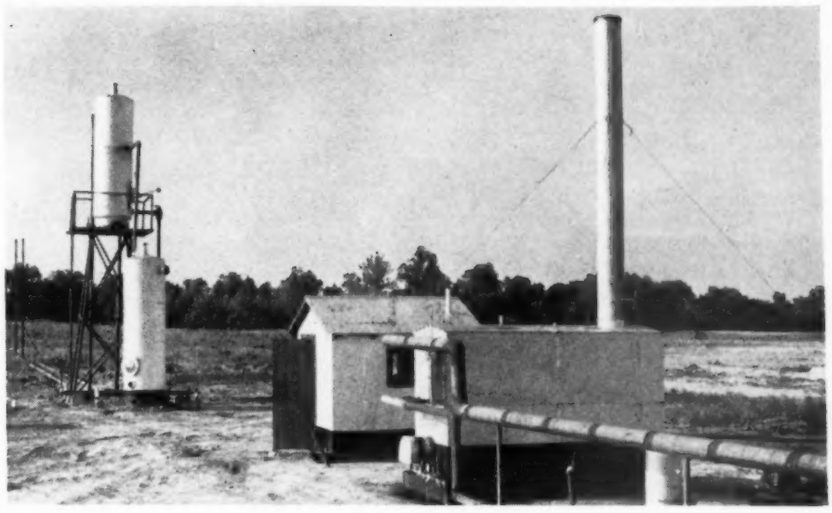
	Charge	*Product*
Gravity, deg. A.P.I.	51.4	51.3
Octane Number, A.S.T.M.	47.2	77.0
Reid vapor pressure	0.4	8.2
	°F.	°F.
Initial boiling point	222	99
10 percent	250	174
50 percent	292	270
90 percent	367	339
Maximum	436	368

The above inspections show substantial increases in octane number and volatility with a slight decrease in gravity, thus indicating the presence of aromatics in the product. Analysis shows the product to contain 40 to 50 percent of aromatics. From 15 to 20 percent of the aromatics present are toluene, the rest being predominantly xylenes and higher aromatics.

Although the most important application of the hydroforming process undoubtedly will be to produce high-octane motor car gasolines, there are other features of the process that are of importance to petroleum refiners. The process is sufficiently flexible so that either straight-run or cracked gasolines may be reformed, and, in general, the product requires no treatment to render it suitable for the market.

By changing operating conditions, the hydroforming process can produce a high grade aviation gasoline, or can be modified to produce a product having more than 80 percent aromatics. This latter feature of the process is particularly important from a military standpoint, as it affords a means for substantially augmenting toluene production in this country. The total production of toluene in the United States was 20,000,000 gal. in 1939, but the toluene content of the product from the Texas City plant alone is equivalent to an annual production of 5,000,000 gal., or about 25 percent of the total toluene production in 1939.

Equipment used to treat emulsified oil in Storm field — oil and gas separators, oil heater, and gauger's "dog house" are shown



PETROLEUM ENGINEER Exclusive

Breaking Oil-Water Emulsions in the Storm Field, Illinois

☆ Combination of heating and chemical treatment satisfactorily cleans-up oil to pipe-line grade

by

J. C. Albright

OIL produced in the Storm field, south of Carmi, Illinois, has a gravity ranging from 30 to 32° A.P.I. The crude oil has an emulsion cut ranging from 2 to 18 percent, and frequently as high as 25 percent, caused by salt water, the production percentage of which is almost identical with the percentage of emulsion cut. The salt content of this emulsified oil has been determined to be approximately 24 lb. per 1000 bbl. for each 0.1 percent of water. Thus an oil cutting 12 percent, for example, would carry approximately 2880 lb. of salt—principally NaCl in each 1000 bbl. produced. The peculiarity of the situation in the Storm area was that the true percentage of emulsion would not be shown in the customary "grind-out" with a portable centrifuge. After difficulty was encountered in refineries due to chloride corrosion, experiments on sampling showed that, by adding a drop of treating chemical to the sample in the centrifuge tube, oil that showed little or no water would then grind out several percent. Until that time, the pipe-line companies were buying oil on a clean oil basis, with neither the producer nor the carrier at fault, but immediately insisted that adequate treating facilities be installed to reduce the percentage of water and accompanying NaCl salts.

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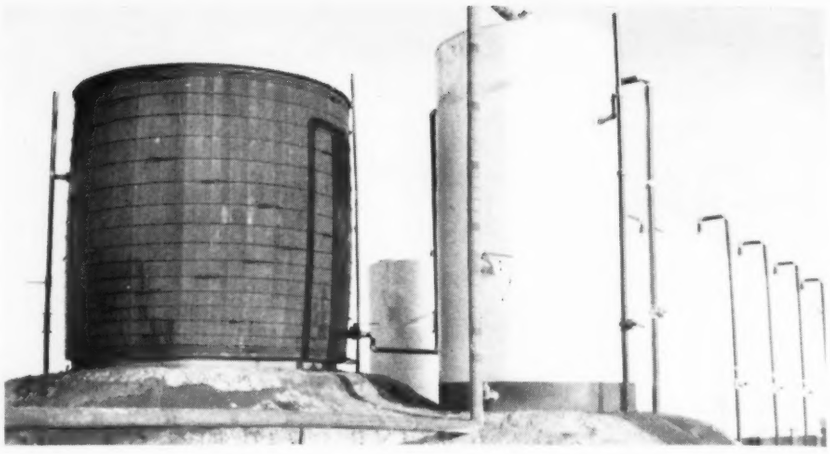
was drilling superintendent for H. J. von Hagen in North Texas area, 1919-1921—With the Noble Oil and Gas Company, Burkburnett, Texas, from 1921 to 1923—Joined staff of the Dixie Gasoline Company in 1923 and became Texas manager—Employed by Phillips Petroleum Company in 1925 and was sent to New Mexico, where the company constructed a natural gasoline plant—Left Phillips in 1929 and for a time operated as a consulting engineer —For last 12 years has devoted virtually all his time to free-lance writing for trade journals.

Because of the peculiarity of the emulsion, settling at atmospheric temperature was not successful, and it was observed that the cut oil should be heated to a high temperature and chemicals added to obtain a satisfactory break. In some instances, heating with the addition of chemicals was not sufficient to reduce the oil to pipe-line grade on a once-through pass from the separators to stock tanks, requiring recirculation by means of pumps. On most leases, however, the once-through application of heat and chemicals reduces the cut oil to a satisfactory pipeline grade.

The type of equipment most commonly employed at Storms for treating emulsified oil consists of the usual stock tank battery, a treating tank with a down-comer or flume, which places the heated oil and emulsion on the floor of the vessel so that when the oil being treated begins to rise, it is forced through a body of warm water



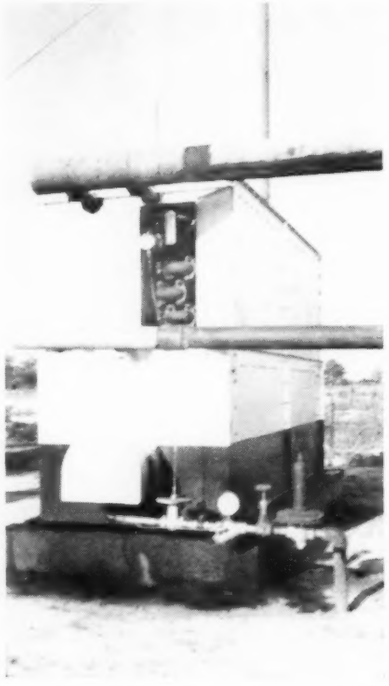
Battery of flow tanks used in connection with salt-water emulsion removal system in Storm field, Illinois

to the outlet at the top. Oil then passes to a second tank for siphoning-off the water released at this point.

The wells are usually single-trapped to separate the oil from the gas, with the flow line running to the battery and water separator. But to heat this oil, and successfully treat it, there is placed in the flow line a tubular-type furnace with automatic equipment for maintaining the required conditions while the well, or wells, flow through the apparatus.

The heater is designed for quick installation, and is built so that it may be moved with a high salvage value. It is all-steel, and contains forty 2-in. tubes equipped with spherical seat removable return bends that provide access to each tube for cleaning or replacement. These tubes are suspended by heavy steel tube sheets, which are an integral part of the framework allowing the tube headers—or return bends—to remain outside for immediate access. The shell of the heater extends beyond the return bends with the enclosure equipped with hinged doors for inspection and to retain the heat. Baffles between each run of tubes are arranged to force the hot gases around the fluid heating tubes before leaving through the furnace stack. The interior arrangement of the heater is such that radiant heat is absorbed by the tubes without impingment of the flames upon the surfaces. The angle-iron framework is enclosed with a sheet metal housing, and the combustion chamber lined with common red brick, laid up dry.

In the 20-tube heater, a single burner is sufficient to maintain any desired temperature on the outlet piping of the heater. Heat, obtained by burning natural gas, is controlled by a thermostat controller and fuel valves. Gas is piped from the lease and reduced in pressure by the controllers, and burned in the combustion chamber in quantities to maintain the necessary temperature on the oil leaving the heater.



Close-up view of the oil heater, a part of the equipment used in breaking salt-water emulsions

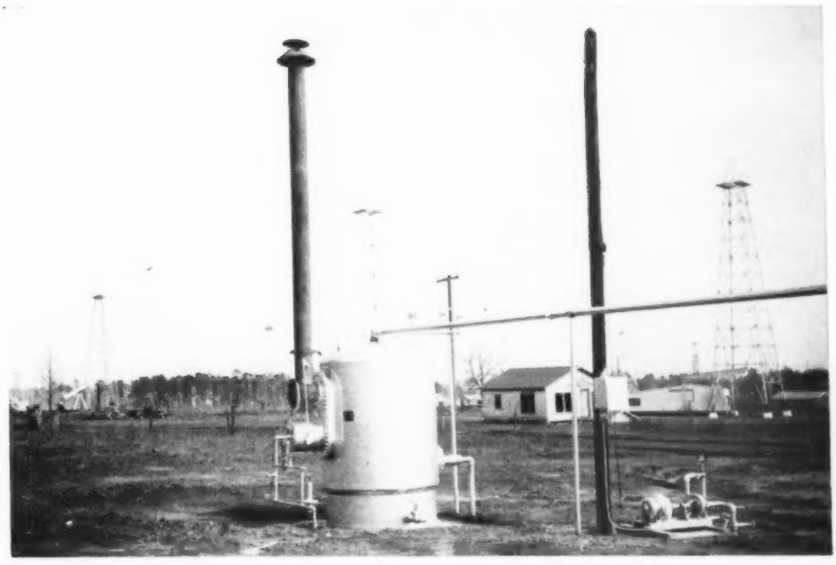
With this type of oil heater, a chemical feeder, set between the unit and the separating tanks, automatically feeds the required quantity of chemicals into the cut oil. Both the chemical feeder and pump are set on a small concrete pier conveniently situated for servicing by the pumper.

The degree of heat necessary to effect a satisfactory break-down of the emulsified oil has been given considerable study by producers, pipe-line companies, and the manufacturer of the equipment, and from tests conducted in the field on various cut percentages, it has been found that 140°F. is sufficient. A reduction of temperature is possible when the recirculating pump is used, which in turn, obviously reduces the vapor losses of the oil in the stock tanks.

The percentage of cut in the production was highest immediately after the wells were drilled, when gas-oil ratios frequently were as high as 65,000 cu. ft. per bbl. of fluid produced. By reducing this ratio, the cut has been reduced proportionately, which in turn has reduced the load on the heaters and reduced the consumption of treating chemicals. A number of different types of chemicals are used in this area, and the consumption varies rather widely, from 2 qt. to 2 gal. per 100 bbl. of oil. The variation of this chemical consumption is governed largely by the quality of material used, but the actual chemical costs are fairly uniform throughout the field, running from 1¼ to 1½ cents per bbl. of oil.

Chemical feeder and recirculating pump

Heating unit of equipment used in treating tank bottoms



PETROLEUM ENGINEER Exclusive Feature

by Frank H. Love
Managing Editor

Reduction in Paraffin Deposition Aids East Texas Gathering Line Operators

☆ Records indicate that curtailed oil production has decreased amount of paraffin collected in gathering lines

PARAFFIN in East Texas gathering lines, long one of the major problems with which pipe-line operators in the area had to contend, now represents in most instances merely another of the routine "headaches" of line operation. In the early days of the field, paraffin in these lines so seriously hampered operations that any and all means of combating the problem were probably tried at one time or another. Many companies began the compilation of records as an approach to the study of conditions so that the best plan for removing paraffin could be determined. Many of these records have been continued down through the years and much valuable knowledge has resulted from a progressive study of the compiled data. During the first several years of the field's development, the volume of paraffin accumulations increased steadily. A close check had to be made because periodic changes in the schedule of control operations were necessary. Although minor changes are still made from time to time in methods of handling the paraffin, the volume of paraffin settling-out in field lines, based on the amount of oil produced, has now virtually "leveled-off."

From the first, the running of scrapers has been the method most generally employed to remove paraffin from lines. When gathering lines were laid, and tank batteries and pumping stations constructed, the work was done according to a standard plan so that scrapers could be run with minimum interruption to flow of oil. The relatively few changes in design that have been made since the original installations will be discussed later.

Inasmuch as the installations thus conform generally to a standard pattern, the principal problem has involved a determination of the most efficient schedule for running scrapers through the various lines. As a means of formulating the cycle or frequency of scraper runs that would attain optimum results, some companies have maintained a detailed tabulation of the amount of paraffin removed from their lines. These data show the volume of paraffin removed per 1000 ft. of pipe per year. One company's records involve all lines operated by it in the field so that the information has permitted an efficient schedule to be adopted.

The peak of paraffin accumulations was reached in 1936. Since that time the trend has shown a gradual decline. Tables 1 and 2 were compiled from records kept by one major company in the field. The number of wells served by this company totals 3000. The figures, therefore, do not represent exact conditions in the entire field, but they do indicate in a general way the tendency with respect to accumulations. The experience of other companies, although their records were not kept in such detail, relates a similar story.

These tables, as well as Fig. 1, which was plotted from data based on the company's 4-in. gathering lines, tell the same story: that from the discovery of the field until the winter of 1936, paraffin accumulations were on a steadily upward trend; since that time the accumulations have gradually declined. Several reasons are given for this decline: (1) more widespread treating of oil by producers, (2) lower well allowables, and (3) a greater curb on the running of "hot oil." The last two points relate to the amount of oil produced, the larger the volume of production the greater the volume of paraffin produced with consequent increase of accumulations in field lines.

The aim of all companies in recent years has been to consolidate their activities to facilitate the removal of paraffin from lines or to reduce its accumulation whenever possible. When a change in a type of hook-up or an operating method is indicated this is done. As an example, some companies are "streamlining" their gathering system hook-ups. This consists of eliminating as many scraper pockets at tank batteries as possible, resulting in longer scraper runs. Time and labor costs are

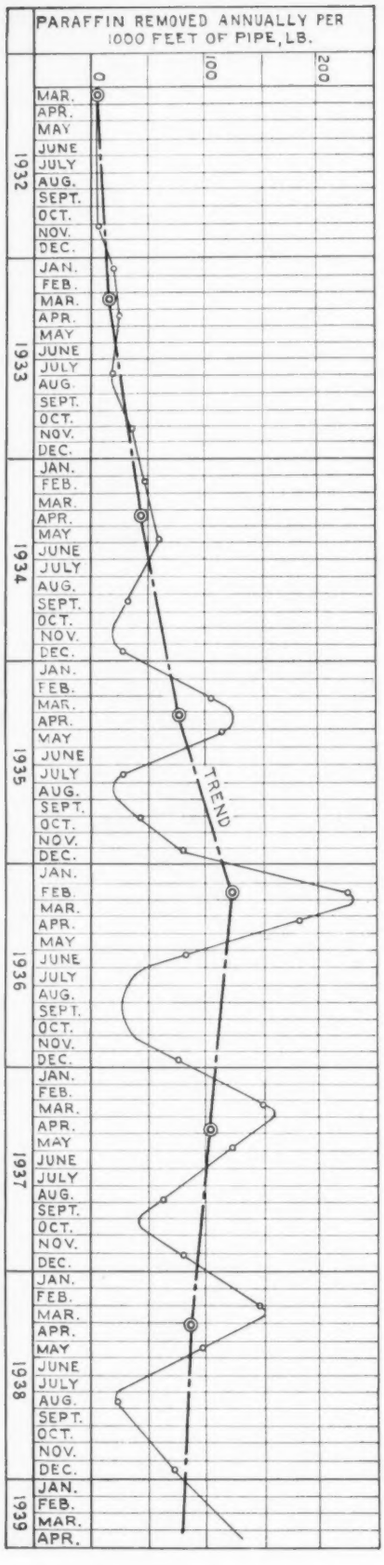


Fig. 1. Curves plotted from one company's records, which show how paraffin accumulations became steadily heavier until the winter of 1936 and have gradually declined since

thus reduced. "Streamlining" has been, and is, done gradually as a chronic condition arises and it is believed that the time required to clean a line is disproportionate. When this condition exists, the time and expenditure involved in "streamlining" is believed justified.

Although the cleaning of field tank bottoms is a function of the production department, it has been found that when this is done frequently the assistance to the pipe-line department is inestimable. A clean tank bottom eliminates the possibility of bottom sediment becoming "riled" and entering the tank discharge lines. On leases where salt-water emulsions require that the crude oil be treated, it has become the practice to use this equipment to heat the tank bottoms and salvage the pipe-line oil. By thus circulating the oil after each pumping-out of a tank of oil, tank bottoms are kept in good condition. One type of equipment used for this purpose is shown in an accompanying illustration. In operation, tank bottoms are pumped to the gun barrel, entering through a flume at the top. The flume extends almost to the bottom of the gun barrel. In the gun barrel, hot salt water is maintained to a depth of approximately 8 ft. The tank bottoms pass through the hot salt water and as the good oil is of lighter gravity it rises to the top of the gun barrel, being then returned to the stock tanks. The salt water is pumped from a gas-fired heater to the gun barrel in continuous circulation, a small motor driving a centrifugal pump usually being employed for the purpose. The heater has a heating capacity of approximately 400,000 B.t.u. per hour and a working pressure of 25 lb. per sq. in. Another method of heating tank bottoms in the gun barrel is by means of steam supplied by an oilfield-type boiler.

To propel scrapers through the lines, some companies have adopted the pressure system entirely, whereas others use static head of the tank batteries to as great an extent as possible, supplementing with pumps whenever this proves insufficient to move the scraper through the lines. Pumps used are of the portable type. They vary somewhat in size and type. One company, for instance, uses two types: A low-volume, high-pressure pump for its smaller-diameter lines that will pump 60 bbl. of fluid per hour at 600-lb. pressure. The other type, for larger-diameter lines, is a high-volume, low-pressure pump that will move 250 bbl. of fluid per hour at a pressure of 150 lb. These are rotary pumps driven by gas-gasoline engines. Other types used are piston-type and steam pumps.

Two practices are followed with respect to removal of the paraffin from the lines when scrapers are run. Some companies discharge the paraffin at field stations, except in rare instances when the line may be so badly clogged that it becomes necessary to remove the paraffin in the field before it reaches the station. Other companies have adopted the practice of moving the paraffin from one line to another until it eventually enters the trunk system. The paraffin, therefore, is never removed from the lines until the oil reaches its final destination. A certain company that adheres to the latter procedure has adopted the practice of running a stripped scraper, one with a part of the knives removed, taking from the inside walls of the pipe on each run only a portion of the paraffin accumulated. This has the effect of never clogging field lines nor making it necessary to remove the paraffin in the field.

In summarizing, the time period between scraper runs has been definitely lengthened. It is no longer necessary that a crew be employed full-time for removal of paraffin. The regular maintenance crew can handle the work along with its other duties, and the per unit cost for paraffin removal has been proportionately reduced.

TABLE 1

No. of lines	Size, in.	Gross length, ft.	Paraffin removed per 1000 ft. of pipe per year, lb. Fall 1936	Winter 1936-37	Spring 1937	Summer 1937
16	3	104,425	29.2	114.6	87.7	15.2
130	4	370,055	68.8	140.6	113.1	57.7
6	5	35,600	53.1	211.2	213.6	138.2
14	6	85,145	289.0	577.5	379.8	196.1

TABLE 2

No. of lines	Size, in.	Gross length, ft.	Paraffin removed per 1000 ft. of pipe per year, lb. Fall 1937	Winter 1937-38	Spring 1938	Summer 1938	Fall 1938	Winter 1938-39
29	3	173,440	42.5	51.6	53.3	14.4	25.6	50.0
154	4	360,715	72.1	132.8	90.3	20.2	68.7	113.2
14	5	98,725	33.4	194.3	162.1	45.3	58.4	84.9
22	6	140,145	205.7	376.1	224.7	88.0	289.6	183.2

Machine Design Problems Encountered in the Petroleum Industry

☆ **Design problems peculiar to oil-field service require special study — bearings, bolts, and gears among machine elements that deserve close attention**

by M. L. Begeman and V. L. Doughtie

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V. L. DOUGHTIE

is professor of mechanical engineering in charge of machine design at the University of Texas—Formerly was a member of the mechanical engineering faculty at Texas Technological College, Lubbock, Texas, and The Johns Hopkins University, Baltimore, Maryland—Received B.S. degree in mechanical engineering from The University of Texas in 1920, and an M.S. degree from the same school in 1940—Is a member of the Society for the Promotion of Engineering Education and the American Society of Mechanical Engineers—Is a registered professional engineer in the State of Texas.

THE petroleum industry has experienced rapid growth and many changes have taken place in all phases of its activity. Until recent years, little attention had been given to the design problems encountered in this comparatively new industry. Machines designed for other industrial applications were frequently adapted for use under entirely different operating conditions. Little attention was given to design, operating efficiency, and life. Large returns from the wells minimized the necessity for proper equipment and that which failed was replaced without much attempt to salvage it. The industry today is in a period where economy is essential in all departments. Conditions are more stable and changes are not so rapid. One possible source of economy is in the proper design of the machinery and equipment used. More thought must be given in the future to economical operation and to low maintenance costs. A machine designed just "to get the job done" is not sufficient. This article will be limited to a discussion of machine design practice with special emphasis placed upon problems encountered in the petroleum industry.

Equipment design in the petroleum field presents many difficulties, some of which are not to be found in other industries. Loads in many cases are unknown and must be estimated. Frequently the machinery is subjected to severe atmospheric conditions. Also the selection of equipment is difficult as it lacks standardization. Much of it has been designed for other purposes and adapted to oil-field work to fill an immediate need. Further, the materials being dealt with are both corrosive and abrasive. Recent drillings deeper than 10,000 ft., with pressures in excess of 10,000 lb. per sq. in., present rather unique and special problems not encountered elsewhere.

Commendable work has been accomplished by the special committees of the A.P.I. in their attempts to standardize certain parts and materials used by the industry. Most of this work includes such items as threaded joints, flange designs, pipe sizes, fasteners, drilling tools, workmanship, and correct procedure. They are principally dimensional specifications and do not cover to any great extent physical and chemical properties of materials or correct design from a standpoint of strength and fatigue. This viewpoint is correct, as a manufacturer should not be limited by too many detailed specifications if he is to produce the best working unit. The general design must be left to the manufacturer, but in many cases he can be helped materially by the standardization of such machine elements as are common to other pieces of equipment.

Each design problem requires a special approach depending on the conditions that must be fulfilled. All the following factors should be at least considered in a properly designed member: strength, rigidity, fatigue, corrosion, wear-resisting qualities, safe operation, and economical operation. Some thought should be given to general appearance, but in equipment of this type it is not of primary importance. Accessibility, ease of repair, and lubrication are to be expected in any good design.

One of the most difficult items to determine in machine design is the allowable or design stress. This stress is defined as the ultimate strength of a material divided by the factor of safety. Usually the ultimate tensile stress and yield point in tension are known, but information regarding shear, compression, and endurance limits is frequently not available. The sec-

ond item, factor of safety, is often "just a factor" used to obtain the design stress. As defined above it should be termed the apparent factor of safety. It has been called by some a "factor of ignorance." With increased knowledge of materials and improved methods this factor should be more wisely determined. A method of estimating the factor of safety will be outlined to give an idea of the points to consider.

Determining Safety Factor

First the type of loading should be determined, that is, whether the load is static or dynamic. With static loads the real carrying strength of a material is the yield point. Under such conditions the apparent factor of safety is the product of two factors, one to reduce the strength of the material from the ultimate to the yield point and the other, called the real factor of safety, is to care for emergencies and unknowns. Putting this in the form of an equation we have:

Apparent factor of safety = a × b,
where:

$$a = \frac{\text{Stress (ultimate)}}{\text{Stress (yield)}}$$

This factor varies from 1½ to 2

b = Real factor of safety
= 1½-2 for steel
= 2-3 for cast iron
= 3-4 for wood.

Imperfections in the material, unknown loads coming upon the member, and in some cases the theory used in design not covering the particular case in hand are situations with which the designer must cope. If the designer could depend on his material, knew that the loads were accurately determined and that the calculated stresses were correct, the real factor of safety could be only slightly more than unity. A typical example of questionable theory is that of determining whether a member is in pure compression or is in column action. The casing of a deep well illustrates the difficulty of determining the load. If the casing is not supported the upper joint is in tension due to the weight of the remaining joints. If the lower part of the string is cemented and the tension relieved, then column action sets in, provided the walls do not offer support. Also the lower end is at a higher temperature than the top, causing temperature stresses. Hence the exact load and resulting stresses are impossible to determine. To illustrate further, a casting may have a blow hole and the strength of the material is below that expected. In both cases the need of a real factor of safety is evident. When the unknowns are more pronounced a larger factor is needed and, vice versa, if the unknowns are reduced a smaller factor should be used. In any case, the exact properties of the material should be known; a reasonably accurate determination of the loads should be made if possible, and a proved design theory should be used in determining the induced stresses.

The real carrying strength for live loads depends not upon the yield point but upon the endurance limit of the material. If the endurance limit for the type of load applied is known, therefore, the design stress would be determined by dividing the endurance limit by a real factor of safety as discussed above. The endurance limit will depend upon the type of loading; that is, whether the load is reversed in one direction or complete reversal, upon the number of repetitions of stress, and whether gradually applied or impact. For live loads we have the following expressions:

Apparent factor of safety =
b × c × d × e,
where

b = Real factor of safety with values same as above

$$c = \text{Reversal factor} = 2 - \frac{s(\text{min})}{s(\text{max})}$$

where s(min) and s(max) are the minimum and maximum stresses or loads coming upon the member each cycle. Values vary from 2 to 3.

d = Repetition factor to care for more than 5,000,000 repetitions =

$$\left(\frac{\text{Number of repetitions in the member}}{5{,}000{,}000}\right)^{0.139}$$

For less than 5,000,000, d = 1
For 50,000,000, d = 1.37
For 500,000,000, d = 1.87

e = Shock or impact factor
= 1½ to 2

Assuming 500,000,000 repetitions the apparent factor of safety for reversal in one direction will vary from 7.5 to 15, and for complete reversal from 11 to 22. The latter figures are high, but in some types of members, as the connecting rod of an internal-combustion engine, 22 is the recommended apparent factor of safety for the crankpin end. With apparent factors of safety (commonly called factor of safety) varying from 3 to 22, it is readily seen that determining the design stress is one of utmost importance and will often tax the ingenuity of the designer.

Any design problem should be reduced to the actual design of the various elements of the machine such as the links, gears, fasteners, belts, etc. A machine may be excellent from the standpoint of the general arrangement of these elements, but if they are not properly designed the unit is a complete failure. The two possibilities for better design, therefore, are the improvement of the arrangement or assembly of the machine elements and of the component parts of the machine. In most cases it is the latter possibility that offers the greatest opportunity for improvement. Quite obviously this discussion will have to be of a general nature as space will not permit a detailed design analysis of the many problems that may be found in oil-field equipment. A few of these problems will be discussed and some possibilities for improvement pointed out.

Bearings

One of the problems encountered is the proper design and protection of bearings. As bearings in oil-field equipment are subjected to rather severe duty, they should be adequately protected from dirt, water, and chemicals, and receive proper lubrication. Although many bearings are protected by various types of seals or packing to prevent the ingress or egress of liquids and foreign matter there are numerous others that lack protection. The purpose of these seals may be either to exclude water and chemical solutions or to insure the retention of the lubricant. Leather and felt have been widely used, but in recent years oil-proof synthetic materials and rubber compounds have been developed that have proved successful to 300°F. The proper selection depends upon the type of fluids in question. These seals are held in place by a metal retainer to prevent rotation, and should be mounted close to the bearing to eliminate possible whip action opening up the seal. They should be compact, have an automatic take-up, and a low coefficient of friction.

For the protection of sliding surfaces, wipers or scrapers should be used that prevent dirt or liquids from entering between the sliding surfaces. Brass or bronze scrapers are effective in keeping out dirt and if properly mounted their edges are self-sharpening. Felts, leather, and synthetic rubber may be used either separately or in combination with a metal wiper to keep out liquids. Whenever possible the machine should be designed with necessary guards, fabric aprons, telescoping tubes, etc., to keep foreign matter entirely from sliding surfaces.

For medium-duty bearings where lubrication is a difficult problem, consideration should be given to one of the applications of powder metallurgy[1], the so-called oil-less bearing. Bearings

[1]"Powder Metallurgy Has Great Design Possibilities," by G. Z. Griswold, *Machine Design*, January, 1940, Vol. 12, No. 1.

of this type may have nearly any desired composition, but are usually copper and tin with a small amount of graphite to assist in the lubrication and provide the necessary porosity. The voids, which constitute about 40-50 percent of the volume, are impregnated with oil that is brought to the bearing surface by capillary attraction. If additional lubrication is desired it may be obtained by having the outer surface of the bearing in contact with an oiled felt or oil reservoir. Bearings of this type will carry rather heavy loads as they have a Rockwell C hardness of about 70 and a tensile strength of 15,000 lb.

Heavy-duty bearings should be of the anti-friction type, preferably roller bearings. They should be exceptionally well-protected from dirt and corrosive liquids, and should be self-aligning to eliminate excessive load conditions. Failure of this type of bearing is frequently due to surface fatigue of the rolling parts or the bearing race, causing a pitting or flaking of the surface metal. An accurate knowledge of working loads to insure proper design will assist in solving this problem.

Bolt Design

A bolt is one of the most common machine elements used, yet its design is very indefinite and often not considered except to say it "looks about right." At the November, 1939, A.P.I. meeting, A. B. Chapman presented a preliminary report on the shearing stresses in bolts as used in derricks. It would seem that shearing stresses induced in bolts should be known, but one need only search briefly the literature on bolts to conclude that such is not the case. What is the procedure for designing a bolt for fixing the head on a cylinder? The working stress is a function of the diameter, decreasing as the diameter is reduced. A much used formula proposed by Seaton and Routhwaite, is $s_w = C(A_r)^{-0.416}$ where s_w is the working stress; C is a constant depending upon the ultimate strength of the bolt material[2], and A_r is the root area. The bolt size is determined by assuming the bolt to be in pure tension. Then the load due to tightening the nut is estimated from experimental data obtained at Cornell University in which it is shown that this load amounts to approximately 16,000 times the nominal diameter. The stress resulting from the initial tightening is added to the total stress resulting from the applied load, to obtain the total stress in the bolt. Factors have been proposed that give the amount of stress resulting from the applied load to be added to the initial tightening stress. Now where are the pitfalls in such design? The factor C used in determining the working stress is questionable. The resulting stress is of doubtful value because the effect of different types of gaskets and metal-to-metal contact is not definitely known. Bolt sizes according to this procedure are often unreliable and the designer must use his judgment in making a desirable selection. Further research to find a rational design is desirable.

[2] C = 5000 for mild steel bolts of less than 1¾ in. diameter.
C = 7000 for mild steel bolts of greater than 1¾ in. diameter.

Effect of Research

An example of the effect of research upon design is found in the design of gear teeth. From 1893 to 1931 the design of gear teeth was based entirely upon the strength of the teeth as obtained by formulas advanced by Wilfred Lewis in 1893. New materials and improved methods of gear manufacture have produced better teeth. Gears designed by the Lewis method did not fail due to strength but failed due to wear. In 1931 Professor Earle Buckingham presented the report of an A.S.M.E. special research committee on the strength of gear teeth. In designing teeth by the findings of this committee, the designer not only considered the strength of the teeth but the dynamic load due to the different methods of cutting the teeth, and wear. With high speeds and poor gear cutting, the dynamic load is considerable. In calculating the tooth proportions, the designer determines the permissible error without noise for the desired pitch line velocity and then selects the type of gear cutter needed for the desired pitch. This means that high speeds require precision-cut gears; if the speed is not high a larger error is permissible and a cheaper gear can be used. The wearing qualities of gears depend largely upon the material used. As a general rule two mating gears will wear longer if each is made of different material; however, mating gears of cast iron have excellent wearing qualities and constitute an exception to this rule. Increasing the hardness of the tooth surface also results in improved wearing ability. This new method of designing gears gives the designer a more exacting method of procedure and a resulting gear that will meet requirements.

A serious problem in the operation of all field equipment is excessive wear on parts used in drilling operations and machine parts in contact with abrasive fluids. The industry was quick to adopt hard facing on drilling bits due to the tremendous possibilities for saving, but to realize these savings to the fullest extent necessitates a careful study of the available hard-surfacing materials and their properties. Unfortunately it is not practical to rate hard-facing materials by wear tests as the type of wear differs greatly from one application to another. Ratings based on sliding friction differ considerably from those based on rolling contact, or on a combination of rolling and impact. Hardness tests cannot be used as a criterion entirely although hardness is an important property for such material. In general, wear resistance will increase as the hardness increases, but when impact is associated with abrasion some hardness must be sacrificed to obtain the necessary toughness required to resist impact. Hence the fact that a drill bit has been hard-surfaced does not imply that it will give the best service. Many new materials have been developed recently, and various techniques are employed in their application. These materials and methods of application must be known and considered in connection with actual service conditions to obtain best results.

Many possibilities to increase wearing service also exist in other types of oilfield equipment. Pump linings, and steel cylinders, may be hard-faced by centrifugal casting with uniform coatings varying from 1/64 to ¼ in. The proper finish is obtained by grinding or honing and no subsequent heat treatment is required. Maintenance costs on exhaust valves and valve seats may be reduced to a minimum by hard-facing. The same applies to clutch jaws, reamer tools, impeller tips, and many other parts. In some cases surface hardening obtained by heat treatment or some special chemical process is the only practical solution to the problem. Pump rods and shafts may be nitrided or chrome-plated to resist wear and corrosion. Flame-hardening is now widely used in connection with the surface hardening of gears and sprockets. Such treatments give hard wearing surfaces with the ductile backing so necessary on applications of this type. Designers must recognize the possibilities that are now available for improving wearing surfaces.

Surface preparation is an important factor in reducing fatigue failures. It has long been known that the endurance limit of a material is greatly increased by eliminating tool marks, by filleting corners, and by exercising care in handling to avoid surface marks. Exposed threads on a drill collar or similar parts are a serious source of weakness due to stress concentrations existing at these points. The elimination of threaded joints, by resorting to resistance or flash welding, may be the solution of such a problem. Care

in manufacture, correct design form, and the proper selection of the production process are all-important factors in reducing fatigue failures. These considerations apply equally well in problems involving corrosion fatigue.

Parts subjected to fatigue stresses may be designed with some degree of accuracy as the endurance limits of most commercial materials have been determined by suitable tests. When a part is subjected, however, to corrosive influences simultaneously with repeated stresses a very difficult problem is presented. In oil-field work a most serious condition occurs in the presence of hydrogen sulphide. The endurance limit of ordinary commercial steels is greatly reduced due to the embrittling action of the hydrogen and by the stress concentrations in the corrosion pits. For easily corroded steels there is no corrosion-fatigue limit and any such steel will ultimately fail even though the load is small. Failure may be long delayed if the applied stress is small. If the steel is completely resistant to corrosion it will have an endurance or fatigue limit under all corrosive conditions very similar to that which it would have if tested in ordinary room conditions. There is no relationship between the tensile strength of a material and its corrosion-endurance limit.

Material Selection

Considering the above facts, improvement in corrosion-fatigue problems is primarily a question of material selection. Such parts as sucker rods, tool joints, drill pipe, and pump rods should be designed with this fact in mind. The cost of corrosion-resistant materials must be weighed against such considerations as probable life of service and economies resulting from continuous operation. Such a selection is a difficult matter as corrosion-fatigue resistance is a function of the actual service conditions or method of loading the member, as well as the kind of corrosive material involved.

Wire ropes have many applications around an oil field and are frequently a source of trouble and expense. The problem involved is not usually one regarding the actual design of the rope, drum, or sheave, but rather one of proper selection of this equipment.[3] Wire rope manufacturers have done a great deal to perfect their product and excellent ropes may be obtained for many applications. Most troubles occur due to no consideration being given the bending stresses induced in the rope as it runs over the drum or sheave. As a rope passes onto the sheave it is changed from a straight to a curved line and the stress caused by this bending depends upon the flexibility of the rope and the radius of the curvature. As the rope leaves the sheave a similar change takes place and if these repeated stresses are high the rope will eventually fail by fatigue. Such failures start with small cracks that finally spread over the entire wire section. This is probably the principal cause of wire rope failure, the actual wear playing only a minor part. To keep these bending stresses low a flexible rope must be used if a small sheave is necessary. As the bending stress is proportional to the rope diameter and inversely proportional to the sheave diameter a large sheave should always be used if not limited by space requirements. The total design load is the sum of the direct load, equivalent bending load, plus the load due to acceleration. By multiplying this load by a factor of safety the minimum allowable breaking strength is obtained.

For best wearing conditions the grooves in the drum or sheave should be slightly larger than the rope diameter. Any pinching effect is highly destructive to the wire rope. Proper alignment is also essential in order to avoid rubbing on the side of grooves. For the same reason the fleet angle from sheave to drum must be kept as small as possible. Proper installation and close coöperation with the manufacturer will do a great deal towards improving wire rope installations.

The petroleum engineer deals more with what is termed "tubular goods" than any other one item. This includes tubes, pipes, cylinders, and various pressure vessels. Again an exact method of design is lacking. Theoretical considerations are not sufficient and the designer must rely on experimental results. When one depends upon the latter, the member to be designed must be subjected to similar conditions as those under which the experiment was conducted. Often field conditions can not be duplicated in the laboratory for the exact conditions are not known. In the design of tubular goods, therefore, the designer relies upon "code" or empirical formulas. Experiments have proved that the resulting stresses and wall thickness will depend upon (1st) whether the pressure is external or internal; (2nd) the ratio of the length to the diameter commonly referred to as "long" or "short," and (3rd), the ratio of the wall thickness to the diameter known as "thin" or "thick." A long tube is one whose ratio of length to diameter is greater than six. A thick tube is one whose ratio of thickness to outside diameter is greater than 0.025. The demarcation between thin and thick cylinders is not so well defined. Theoretically it is the point at which the stress can no longer be assumed to be uniformly distributed throughout the entire wall thickness. Some authorities assume a cylinder is thin if the ratio of wall thickness to inside diameter is less than 0.07.

Somewhat satisfactory formulas have been developed for thin and thick cylinders with both internal and external pressure; it is necessary, however, for the designer to know the exact working conditions in order to choose the proper equation. Often these conditions are not known and the designer must rely to a large extent on what he knows to be good practice. Further research is necessary.

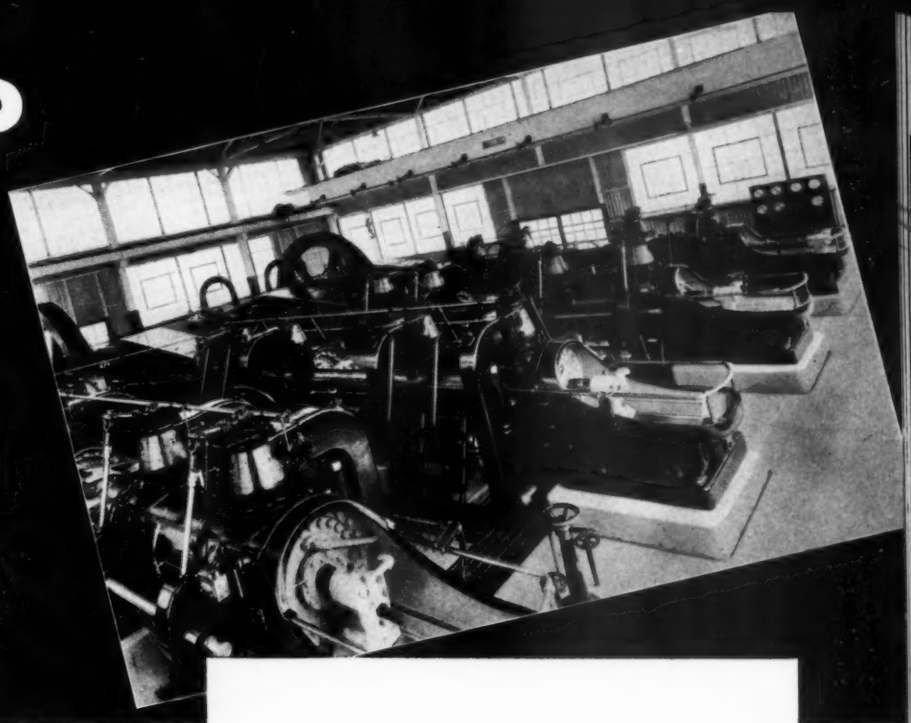
Problems Change

Design problems encountered in the petroleum industry are constantly changing and increasing with improved methods of production. Consider such parts as casingheads, blowout preventers, control heads for Christmas trees, and mud valves designed for tremendous pressures. Cylinder design formulas based on yield stress are of little value as the design is primarily one of keeping deflection or strain in such parts at a minimum. There is also the highly important problem of designing joints and packing that will hold securely under high pressures. In pumping units there is the problem of counter-balance to consider in order to reduce the peak power input to the system and to smooth out the power input curve as much as possible. Oil wells being of such a nature as to vary in power demand from time to time, it is desirable to design a crank with a counter-balance that will lend itself to quick and easy adjustment. The bearings on the walking beam should be properly placed to give uniform polished-rod motion, eliminating any tendency for undesirable whip in the rods. Where misalignment is possible, equalizers and bearings having self-aligning features should be used.

The foregoing discussion touches only a few of the design problems in the petroleum industry, but the examples cited are sufficient to illustrate the possibilities for improvement that may be made. These improvements may be either along the line of improved design of the respective machine elements that make up an assembly, or on the general arrangement and mechanism of the machine. In any event simplicity along with ruggedness, accessibility, and dependability are important characteristics to have in this type of equipment. Materials and manufacturing techniques are continually being improved to assist the designer.

[3] "Drum & Sheave Design," by F. L. Spangler, *Product Engineering*, Vol. XI, No. 1, January, 1940.

13,000 HP for "Southern Natural"



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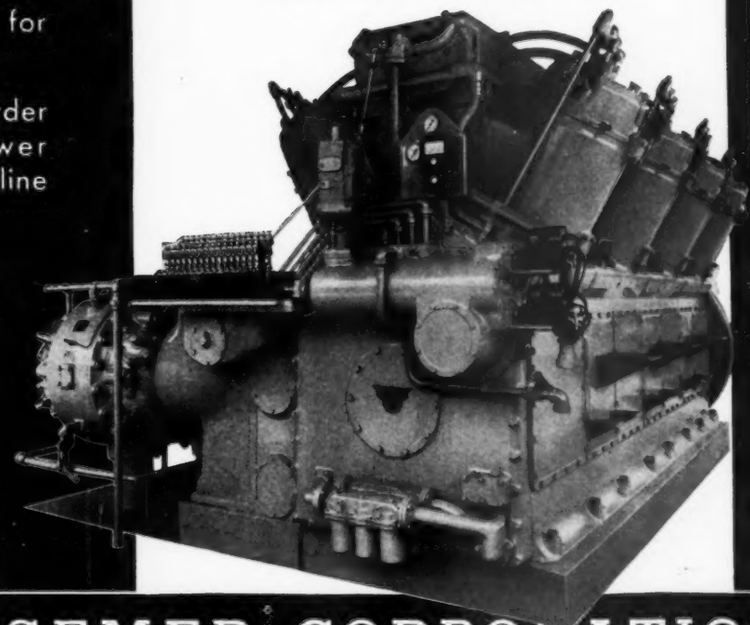

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The Thermal Properties of Lighter Hydrocarbons

☆ A practical method of determining the effect of high pressure on the enthalpy and entropy of natural gases

by George Granger Brown
Professor of Chemical Engineering, University of Michigan
and
Dysart E. Holcomb

GEO. GRANGER BROWN

graduated with a bachelor's degree in chemical engineering from New York University in 1917—Served with the Aluminum Company of America at Massena, New York, with the Chemical Warfare Service at Washington, D. C., then as production manager for the Union Special Machine Company in Chicago, and Youngstown Sheet and Tube Company at Evanston, Illinois—In 1920 joined the staff of the Department of Chemical Engineering, University of Michigan—Post-graduate studies led to the doctor's degree received in 1924—The professional degree of chemical engineer was granted by New York University in 1925.

DYSART E. HOLCOMB

received B.S. degree in chemical engineering from Texas Technological College in June, 1937, and M.S. degree in chemical engineering from the University of Michigan in June, 1938—During summer following completion of M.S. degree worked with technical service division, Humble Oil and Refining Company, Baytown, Texas—For two years and a half he was assistant in the chemical engineering department, University of Michigan, resigning to continue work for his Ph.D. degree in chemical engineering—He also is working with Dr. Brown on high-pressure equilibrium data and computations.

IN AN earlier article a group of curves was presented in which compressibility factors for natural gases were set forth.[1] Additional experimental data obtained since those curves appeared have enabled the plot to be revised[2] and extended to pseudo-reduced pressures of 15. Using the values for the compressibility, $Z = \frac{PV}{RT}$, from the revised and extended plot, the effect of pressure on the enthalpy or heat content of natural gases may be computed as indicated by the following thermodynamic equations:*

$$dH_T = \left[V - T\left(\frac{\partial V}{\partial T}\right)_P \right] dP \quad . \quad (1)$$

substituting:

$$T_r T_c = T \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$P_r P_c = P \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$V = \frac{ZRT}{P} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$dH_T = \left\{ \frac{ZRT}{P_r P_c} - RT\left[\frac{Z}{P_r P_c} + \frac{T_r T_c}{P_r P_c}\left(\frac{\partial Z}{T_c \partial T_r}\right)_{P_r} \right] \right\} P_c \, dP_r \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$\left(\frac{dH}{T}\right)_T = -\left(\frac{RT_r}{P_r}\right)\left(\frac{\partial Z}{\partial T_r}\right)_{P_r} dP_r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$\left(\frac{\Delta H}{T}\right)_T = R \int_{P_r = 0}^{P_r = P_r} \left[-T_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r} \right] \frac{dP_r}{P_r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

In order to solve equation (7) it is necessary to make a cross plot of the compressibility factor, plotting Z as a function of T_r for lines of constant P_r. These curves must then be graphically differentiated in order to determine the values for $\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}$ for substitution in equation (7). The values for: $\frac{-T_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}}{P_r}$ are plotted for constant T_r as a function of P_r. The curves are integrated and the integral values are multiplied by R. The values of $-\frac{\Delta H}{T}$ for an isothermal increase in pressure (P_r) may then be read directly from the integral curve as in Fig. 2.

A somewhat simpler procedure that proves to be considerably more accurate because it involves an easier graphical differentiation and integration is as follows:

Defining the fugacity (f) by the following equations:

$$d\ln f = d\ln P - \left(\frac{1 - Z}{P}\right) dP \quad . \quad (8)$$

$$d\ln \frac{f}{P} = -\left(\frac{1 - Z}{P}\right) dP \quad . \quad (9)$$

[1] See Fig. 4 in "The Compressibility of Gases," by George Granger Brown and Dysart E. Holcomb, *The Petroleum Engineer*, p. 23, February, 1940.

[2] This revised plot is available from the author on 8½ by 11 paper at a nominal cost.

* Table of nomenclature is given at the end of this article.

CEMENTS FOR OIL INDUSTRY SERVICE

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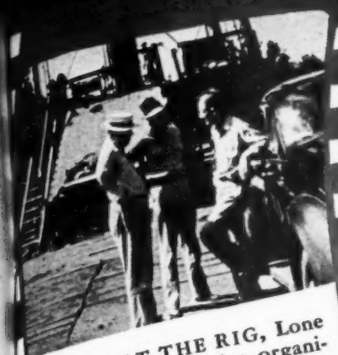
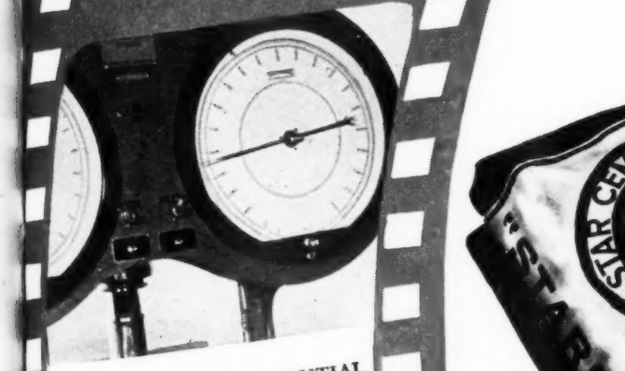


RIGHT AT THE RIG, Lone Star's oil-field service organization studies cementing problems—to keep the men at the mill constantly informed on oil-field requirements.

TESTS FOR NEEDED PROPERTIES and qualities—such as length and ease of pumpability at high temperatures—are part of daily routine.

NEAT-CEMENT TEST SPECIMENS are cured at 140, 170 and 200° F., to approximate the various conditions encountered in oil-well service—



AND STRENGTH, SO ESSENTIAL in oil-well cementing, is constantly checked. Work like this goes on all the time—we call it "keeping pace with progress."

Day in and day out, Lone Star's oil-field organization studies cementing problems right at the rig, to keep an accurate line on the Oil Man's requirements. Close contact with problems in the field enables us to make cements with the properties and qualities needed to meet changing conditions of oil-industry service.

That is why 'Starcor' and 'Incor' deserve to be called the Oil Man's Cements—because they are made to measure for today's oil-industry needs. Use 'Starcor' for deep wells, greater length and ease of pumpability at high temperatures. Use 'Incor' for wells of moderate depth—earlier drill-out, wells on production quicker. Insist on 'Starcor'* or 'Incor'*—it'll pay you well. *Reg. U. S. Pat. Off.

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$$d\ln\frac{f}{P} = -\left(\frac{1-Z}{P_c P_r}\right)P_c\,dP_r = -\left(\frac{1-Z}{P_r}\right)dP_r \quad \ldots\ldots\ldots \quad (10)$$

$$\ln\left(\frac{f}{P}\right)_{T_r} = \int_{P_r=0}^{P_r=P_r} -\left(\frac{1-Z}{P_r}\right)_{T_r} dP_r \quad \ldots\ldots\ldots \quad (11)$$

The logarithm of the ratio of the fugacity to the absolute pressure is readily determined by graphically integrating the righthand side of equation (11). This consists simply in plotting the value for the expression $-\left(\frac{1-Z}{P_r}\right)$ as a function of P_r at a constant value for T_r and determining the area under the curve. The values from the integrated curve are then read directly as the values for the logarithm of the fugacity over the pressure.

This graphical integration has been made, giving the curves shown in Fig. 1, which is a plot of the fugacity divided by the absolute pressure as a function of P_r (pseudo-reduced pressure) for lines of constant T_r (pseudo-reduced temperature).

From this plot the effect of pressure on the enthalpy (H) may be obtained by determining the differential of the values of the logarithms of the fugacity over pressure with the logarithms of the reduced temperature. In order to accomplish this differentiation it is necessary to make a cross plot of the data of Fig. 1 plotting ln (f/P) against ln T_r for lines of constant P_r. The differential of these curves gives directly the isothermal decrease in $\frac{\Delta H}{T}$ brought about by an increase in pressure according to the following thermodynamic equations:

$$F^* - F = RT \ln f^*/f = RT\,(\ln f^* - \ln f) \quad \ldots\ldots\ldots \quad (12)$$

$$\frac{F^*}{T} - \frac{F}{T} = R \ln f^*/f \quad \ldots \quad (13)$$

Differentiating equation (12) with respect to T:

$$\left(\frac{\partial F^*}{\partial T}\right)_P - \left(\frac{\partial F}{\partial T}\right)_P = R \ln f^*/f + RT\left(\frac{\partial \ln f^*}{\partial T}\right)_P - RT\left(\frac{\partial \ln f}{\partial T}\right)_P \quad (14)$$

Substituting equation (13) in equation (14):

$$\left(\frac{\partial F^*}{\partial T}\right)_P - \left(\frac{\partial F}{\partial T}\right)_P = \frac{F^*}{T} - \frac{F}{T} + RT\left(\frac{\partial \ln f^*}{\partial T}\right)_P - RT\left(\frac{\partial \ln f}{\partial T}\right)_P \quad (15)$$

Inasmuch as f equals P at low pressures, then $f^* = P^*$:

$$\left(\frac{\partial \ln f^*}{\partial T}\right)_P = \left(\frac{\partial \ln P^*}{\partial T}\right)_P = 0 \quad (16)$$

$$\left(\frac{\partial F}{\partial T}\right)_P = -S = \frac{F-H}{T} \quad \ldots \quad (17)$$

Substituting equations (16) and (17) in equation (15):

$$\left(\frac{F^*}{T} - \frac{H^*}{T}\right) - \left(\frac{F}{T} - \frac{H}{T}\right) = \frac{F^*}{T} - \frac{F}{T} - RT\left(\frac{\partial \ln f}{\partial T}\right)_P \quad \ldots\ldots \quad (18)$$

Simplifying and adding $RT\left(\frac{\partial \ln P}{\partial T}\right)_P$, which is zero:

$$\frac{-H^*}{T} + \frac{H}{T} = RT\left[\left(\frac{\partial \ln P}{\partial T}\right)_P - \left(\frac{\partial \ln f}{\partial T}\right)_P\right]$$

or

$$-\frac{\Delta H}{T} = \frac{H^* - H}{T} = RT\left(\frac{\partial \ln f/P}{\partial T}\right)_P \quad \ldots\ldots\ldots \quad (19)$$

Substituting equations (2) and (3) into equation (19):

$$-\frac{\Delta H}{T} = R\,T_r\,T_c\left(\frac{\partial \ln f/P}{T_c\,\partial T_r}\right)P_r$$

$$-\frac{\Delta H}{T} = R\left(\frac{\partial \ln f/P}{\partial \ln T_r}\right)_{P_r} \text{ in B.t.u. per lb. mole per } ^\circ \text{ abs.} \quad \ldots\ldots \quad (20)$$

The differentiation indicated in equation (20) has been made by the graphical method[3] and the corresponding values for $-\frac{\Delta H}{T}$ in B.t.u. per lb. mole per ° abs. are plotted for lines of constant T_r as a function of P_r in Fig. 2.

It should be emphasized that in Fig. 2 an increase in pressure causes a decrease in the enthalpy or heat content at constant temperature as indicated by the minus sign before the ΔH. As the reference state for Fig. 2 is at zero absolute pressure, the enthalpy of any gas at any pressure other than a very low pressure may be obtained by simply adding to the enthalpy at zero pressure the negative number obtained for the effect of high pressure on the enthalpy as given in Fig. 2.

The *entropy* of a gas is a most important thermodynamic property particularly when concerned with problems of compression of natural gas.

The effect of pressure on the entropy of a gas may also be determined by well-known thermodynamic relationships from the values given in Figs. 1 and 2 for the effect of pressure upon the fugacity and enthalpy.

From equation (17) we may write equation (21) as applied to an isothermal change:

$$-\Delta S = -\frac{\Delta H}{T} + \frac{\Delta F}{T} \quad \ldots \quad (21)$$

The values for $-\frac{\Delta H}{T}$ may be read directly from Fig. 2, and the values for $\frac{\Delta F}{T}$ may be obtained from the values in Fig. 1 according to the following equation:

$$\frac{\Delta F}{T} = R \ln \frac{f}{P} - R \ln \frac{f^*}{P^*} \quad \ldots \quad (22)$$

It is impossible to determine the effect of pressure on the value of ΔS using zero pressure as a reference state. For this reason a reference pressure of one atmosphere has been chosen and the reference reduced pressure is that corresponding to atmospheric pressure for methane. The values of $-\Delta S$ plotted for lines of constant reduced temperature as a function of P_r in Fig. 3 were obtained by substituting the values from Figs. 1 and 2 as indicated in equation (23).

$$S_{P_r = 0.0218} - S_{P_r} = \left(\frac{H_{P_r = 0.0218}}{T} - \frac{H_{P_r}}{T}\right) + \left(\frac{F_{P_r}}{T} - \frac{F_{P_r = 0.0218}}{T}\right) \quad (23)$$

The decrease in entropy from atmospheric pressure will vary slightly with the pseudo-critical pressure of the natural gas, because the values in Fig. 3 are based on a pseudo-critical pressure of 673 lb. per sq. in. abs., as a reference, which is the critical pressure for methane. If the pseudo-critical pressure for the natural gas differs from 673 lb. per sq. in. abs., the value

[3] T. R. Running, *Graphical Calculus*; George Wahr, Ann Arbor, Michigan, 1937.

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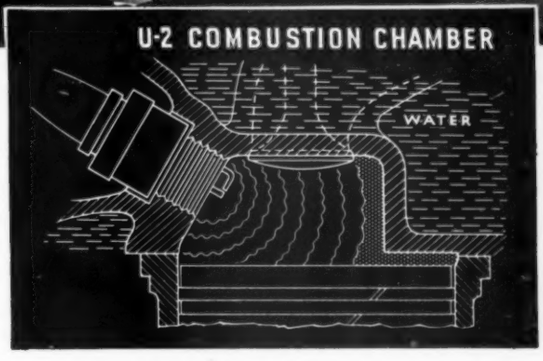

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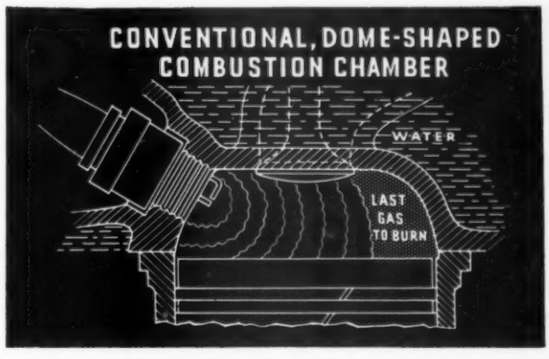

In this type of combustion chamber, the last gas to burn frequently ignites all at once, due to heat of excessively high *pressure* caused by expansion of ignited gas in rest of chamber. This wastes fuel, causes engine "knocking," valve and piston ring sticking, crankcase dilution, smoky exhaust.

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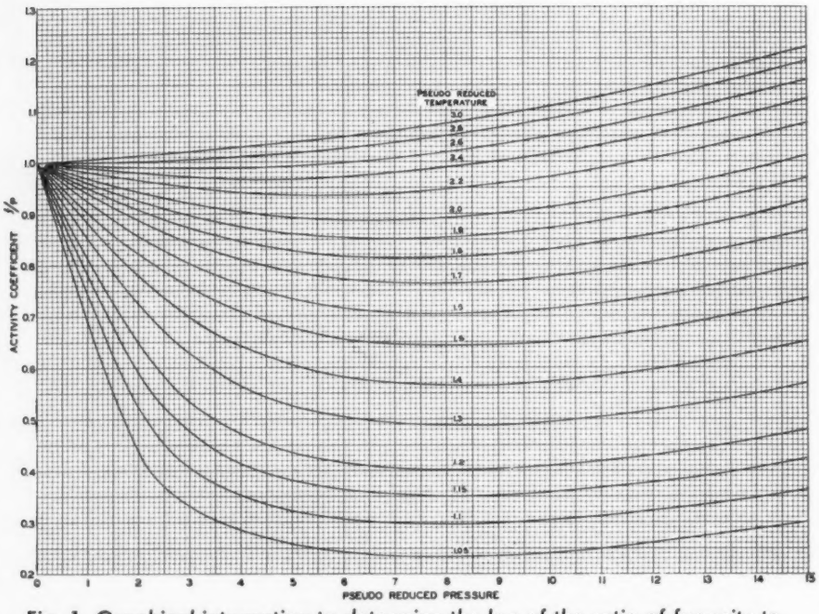


Fig. 1. Graphical integration to determine the log of the ratio of fugacity to absolute pressure

for — ΔS should be corrected according to the small diagram indicated in the lower righthand corner of Fig. 3.

As an increase in pressure causes a decrease in entropy, it should be emphasized that the numerical values indicated for — ΔS on the main chart of Fig. 3 are to be decreased by the quantity indicated in the small diagram in the lower righthand part of Fig. 3 if the pseudo-critical pressure is less than 673 lb. per sq. in. abs. For example, if the decrease in entropy accompanying an increase in pressure to $P_r = 5$ at a reduced temperature of 1.3 is 13.73 as read from the main chart in Fig. 3 for a gas with a pseudo-critical pressure of 673 lb. per sq. in., the decrease in entropy for a gas with a pseudo-critical pressure of 615 lb. per sq. in. would be 13.73 — 0.2 or 13.53.

The effect of temperature on the enthalpy and entropy of a gas at constant pressure is determined directly from the heat capacity by employing the following well-known relationships:

$$\Delta H_P = \int C_p \, dT \qquad . \; . \; . \quad (24)$$

$$\Delta S_P = \int \frac{C_p}{T} \, dT \qquad . \; . \; . \quad (25)$$

The heat capacity of natural gases is plotted as a function of temperature and gas gravity for the light hydrocarbons in Fig. 4. The heat capacity of higher molecular-weight hydrocarbon vapors is also included in terms of the A.P.I. gravity of the heavier hydrocarbons when existing as a liquid.

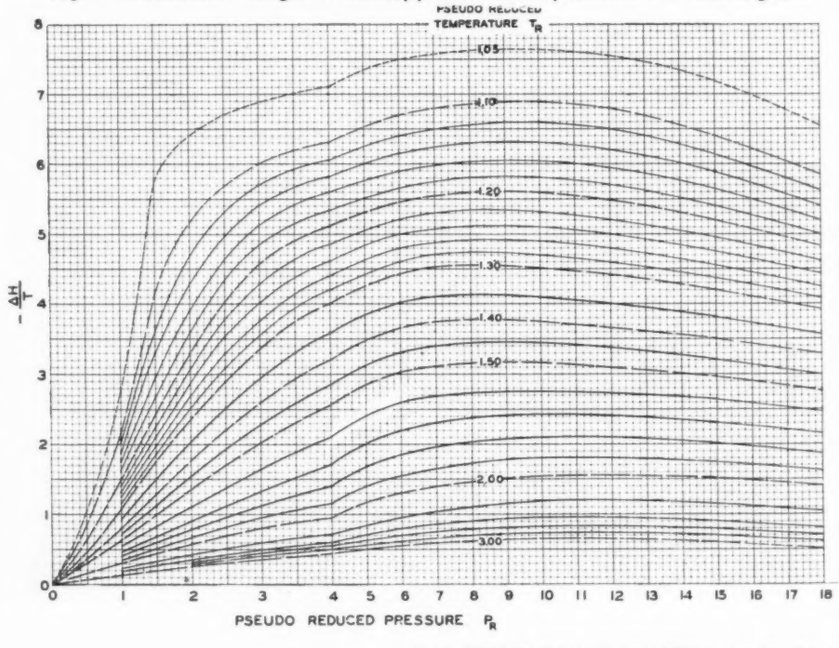
In making heat balances for gases at atmospheric pressure, a reference point of 32°F. may be used and the enthalpy or heat content of the gas at any temperature above 32°F. may be computed from the heat capacity data of Fig. 4 using equation (24). The integration consists simply of determining the area under the heat capacity curve between the temperature limits of 32°F. and the desired temperature as plotted in Fig. 4. The values for the enthalpies (or heat contents) so obtained may then be added and subtracted directly, making a heat balance involving natural gas, provided the gas is always at atmospheric pressure. When the gas is under pressure, it is necessary to correct the values for the enthalpy or heat content as obtained by the graphical integration of the heat capacity versus temperature curve as shown in Fig. 4, by subtracting from the value of the enthalpy at the higher temperature, the value of — ΔH as determined from Fig. 2 using the pseudo-critical temperature and pressure of the natural gas as determined from the composition of the natural gas as described in Table 3 of the article appearing in the February, 1940, issue of *The Petroleum Engineer*.

If the composition of the gas is not available, the pseudo-critical pressure and the pseudo-critical temperature may be estimated from the experimentally determined gravity of the gas by Figs. 8 and 9 appearing in the April, 1940, issue of *The Petroleum Engineer*. In using these last figures it should be kept in mind that gases containing nitrogen or air, or gases of some different ratio of ethane to propane than those used in constructing these charts will not fall exactly on these curves. Gases from East Texas fields show slightly higher pseudo-critical temperatures, but the pressures are almost the same as those determined from these charts.

By determining the effect of temperature and pressure on the enthalpy of natural gas in this manner it is possible to compute in a reliable manner the decrease in temperature accompanying the free expansion of a natural gas such as occurs when the gas is flowed through a choke.

In computing the energy or power required for the compression of a gas, it is necessary to utilize the data of Figs. 2, 3, and 4. If the gas is com-

Fig. 2. Isothermal changes in enthalpy above zero pressure for natural gases



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pressed isothermally, the indicated energy required to compress and deliver one mole of gas may be computed directly from the data in Fig. 1, using the following equation:

$$\text{work of compression} = \int V dP = \Delta F_T = RT \ln f_2/f_1 \quad . \quad . \quad . \quad . \quad . \quad (26)$$

In commercial operation the compression usually occurs over a path that is not isothermal but very close to an adiabatic path. An adiabatic path is a path of constant entropy. It is possible to compute the energy required for the adiabatic compression of a natural gas using the relationships of Figs. 2, 3 and 4. But a far more convenient method is by use of temperature-entropy, or enthalpy-entropy (Mollier)) diagrams. The preparation of such a diagram is usually well worthwhile if a number of computations are to be made on a particular gas, otherwise it may be almost as simple to make the computations from the data of Figs. 2, 3, and 4.

The construction of an enthalpy-entropy diagram for a natural gas is indicated in Table 1.

As indicated in Table 1 the enthalpy and the entropy as given in columns 4 and 5 are taken as zero for the temperature of 32°F. and one atmosphere pressure. The corresponding values for the enthalpy in column 4 at atmospheric pressure and at the higher temperatures as indicated in the succeeding lines of Table 1 were obtained by integrating the heat capacity from Fig. 4 within the indicated temperature range according to equation (25). Similarly the values for the entropy listed in column 5 were obtained by integrating equation (26) using the heat capacity data from Fig. 4.

The values for the enthalpy given in column 4 and the corresponding values for the entropy given in column 5 were plotted in Fig. 5 to determine the position of the atmospheric line therein.

Column 6 of Table 1 gives the value for the expression $-\Delta H/T$ obtained from Fig. 2 for atmospheric pressure. This value is subtracted from the values for this function listed in column 7 for a reduced pressure of 1.505 corresponding to a pressure of 1000 lb. per sq. in. This difference, listed in column 8, is multiplied by the corresponding absolute temperature listed in column 2 to obtain the value for ΔH given in column 9. The value for ΔH in column 9 is added to the value for the H in column 4 to obtain the value for the H or enthalpy in column 11.

The increase in entropy due to the increase in pressure from atmospheric to 1000 lb. per sq. in. as read from Fig. 3 is listed in column 10. The values in column 10 are added to the values of the entropy in column 5 to obtain the values for the entropy as listed in column 12.

The values for H as given in column 11 and for S as given in column 12 are then used to plot these points for the 1000 lb. pressure line in Fig. 5.

The same procedure is carried forth as indicated for the values at 2000 lb. per sq. in. and the values for the enthalpy H and the entropy S as listed in columns 17 and 18, respectively, are used to plot the point in Fig. 5 for the 2000 lb. pressure line.

By making many such calculations as indicated in Table 1 the complete enthalpy-entropy diagram shown in Fig. 5 was obtained for this gas. Fig. 5 is directly applicable only to a natural gas that has a pseudo-critical pressure of 664 lb. per sq. in. abs. and a pseudo-critical temperature of 383° Rankine, but the effects of pressure and temperature on the enthalpy and entropy of other gases closely approximating the gravity of this gas, 0.7, are relatively similar and data computed by use of Fig. 5 for other gases of about this gravity will not be in serious error.

The uses of Fig. 5 may best be explained by the following examples:

Example 1

If the gas of Fig. 5 is expanded freely and adiabatically as through a choke or throttle, from an initial pressure of 5000 lb. per sq. in. abs. and tempera-

Fig. 3. Isothermal changes in entropy

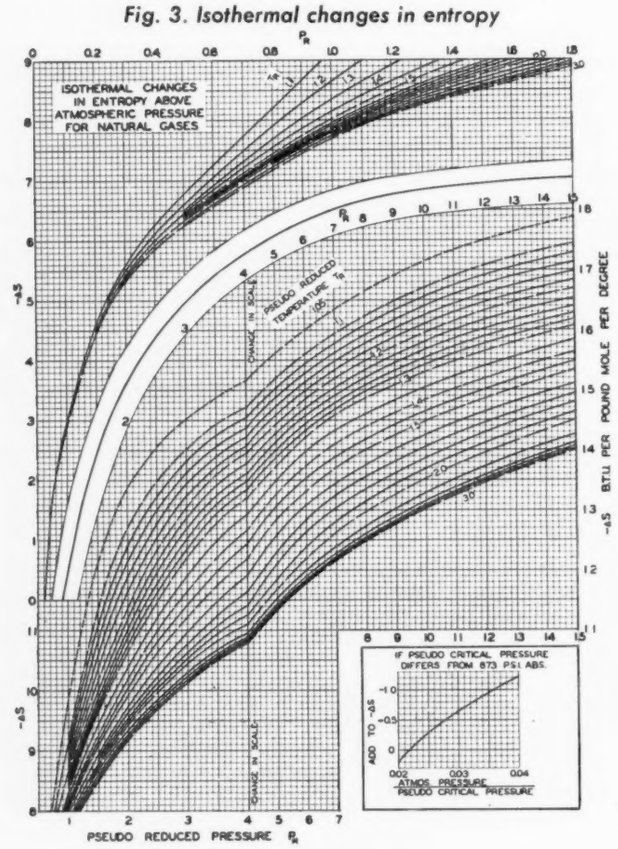
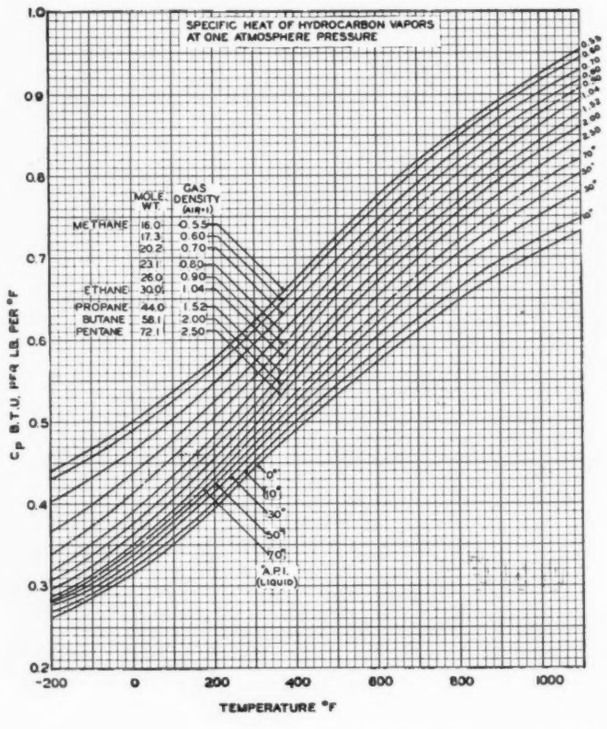

ISOTHERMAL CHANGES IN ENTROPY ABOVE ATMOSPHERIC PRESSURE FOR NATURAL GASES
PSEUDO REDUCED PRESSURE P_R
BTU PER POUND MOLE PER DEGREE
CHANGE IN SCALE
PSEUDO REDUCED TEMPERATURE T_R
1° PSEUDO CRITICAL PRESSURE DIFFERS FROM 673 PSI ABS.
ADD TO -ΔS
ATMOS. PRESSURE / PSEUDO CRITICAL PRESSURE

Fig. 4. Specific heats at atmospheric pressure



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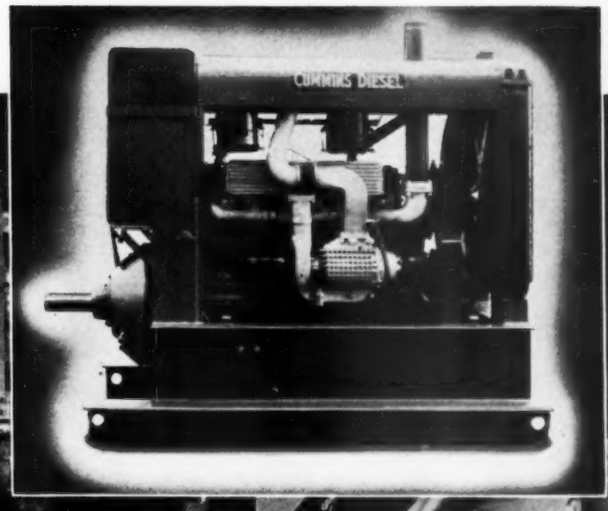

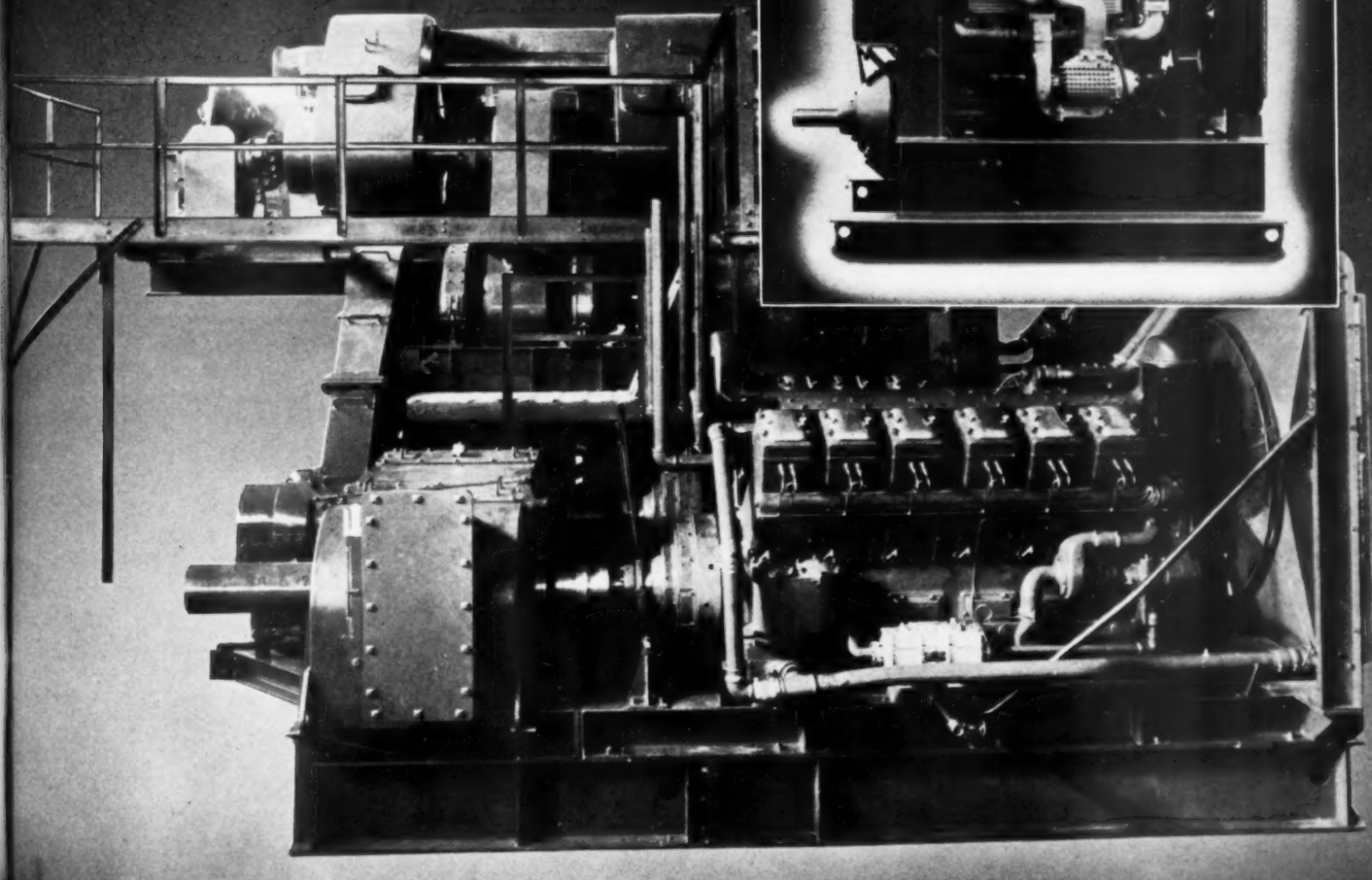

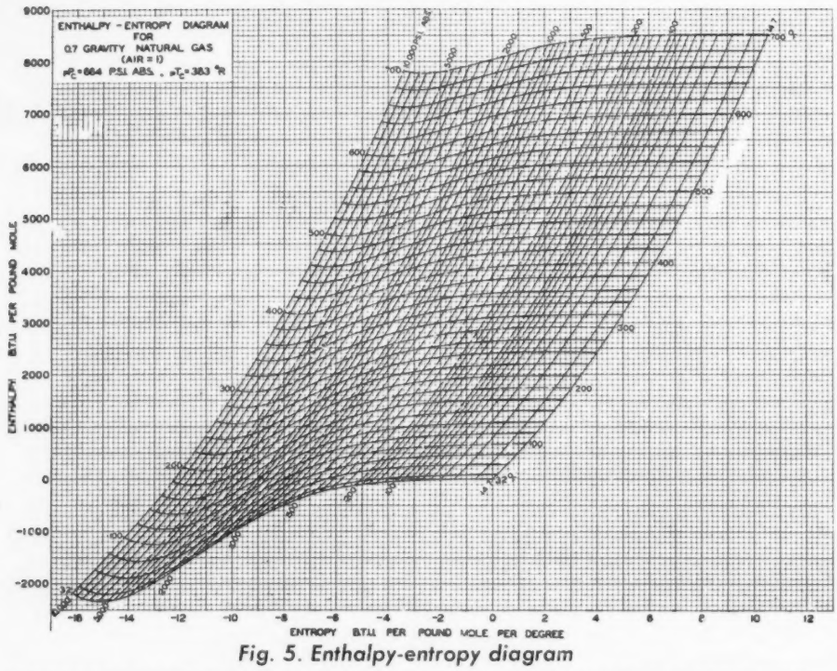
ENTHALPY - ENTROPY DIAGRAM
FOR
0.7 GRAVITY NATURAL GAS
(AIR = 1)
ENTHALPY BTU PER POUND MOLE
ENTROPY BTU PER POUND MOLE PER DEGREE

Fig. 5. Enthalpy-entropy diagram

ture of 160°F. to a pressure of 1000 lb. per sq. in. abs., what would be the final temperature at the end of the expansion?

For free adiabatic expansion in flow the enthalpy (H) is constant.

Referring to Fig. 5:

Initial conditions (1)

$P_1 = 5000$ lb. per sq. in. abs.

$T_1 = 160°F.$

$H_1 = -360$ B.t.u. per mole

Final conditions (2)

$P_2 = 1000$ lb. per sq. in. abs.

$H_2 = -360$ B.t.u. per mole

By following the constant enthalpy line of —360 B.t.u. per mole horizontally across the chart to the intersection of the 1000 lb. per sq. in. abs. pressure line the final temperature is read as 70°F.

Example 2

If 1,000,000 std. cu. ft. (measured at 60°F. and 14.4 lb. per. sq. in. abs.) of the gas of Fig. 5 are compressed isothermally per day of 24 hours at a temperature of 100°F. from 1200 lb. per sq. in. abs. to 3000 lb. per sq. in. abs., what is the horsepower required for compression?

From equation (26):

Work of compression $= RT \ln f_2/f_1$

Initial conditions (1)

$$T_r = \frac{(100 + 460)}{383} = 1.462$$

$$P_r = \frac{1200}{664} = 1.81$$

$f/P = 0.82$ from Fig. 1

$f_1 = 0.82 \times 1200 = 984$ lb. per sq. in. abs.

Final conditions (2)

$T_r = 1.462$

$$P_r = \frac{3000}{664} = 4.52$$

$f/P = 0.664$ from Fig. 1

$f_2 = 0.664 \times 3000 = 1992$ lb. per sq. in. abs.

Work of compression $= 1.987 \times 560 \ln \frac{1992}{984} = 785$ B.t.u.per lb. mole

Volume of 1 mole of gas at 60°F. and 14.4 lb. per sq. in. abs. $= 387$ cu. ft.

$$\frac{1{,}000{,}000}{24 \times 387} = 107.7 \text{ moles of gas per hr.}$$

1 hp-hr. $= 2545$ B.t.u.

$$\text{Indicated hp.} = \frac{785 \times 107.7}{2545} = 33.2$$

The heat to be removed during the compression in order to maintain isothermal compression can be obtained by adding the work of compression as determined above to the decrease in enthalpy as read from Fig. 5.

$H_1 = -100$ B.t.u. per lb. mole

$H_2 = -1000$ B.t.u. per lb. mole

$\Delta H = H_2 - H_1 = -1000 - (-100) = -900$ B.t.u. per mole

Heat removed during compression $= -\Delta H +$ work of compression $= 900 + 785 = 1685$ B.t.u. per lb. mole

Heat removed per hour during compression $= 1685 \times 107.7 = 181{,}475$ B.t.u. per hr.

Example 3

If 1,000,000 std. cu. ft. (measured at 60°F. and 14.4 lb. per sq. in. abs.) of the gas of Fig. 5 is compressed adiabatically (at constant entropy), per day of 24 hours, from 1200 lb. per sq. in. abs. and 100°F. to 3000 lb. per sq. in. abs., what is the horsepower required for compression?

For an adiabatic compression the work of compression is equal to ΔH for the compression.

From Fig. 5:

Initial conditions, (1)

$T = 100°F.$

$P = 1200$ lb. per sq. in. abs.

$H = -100$ B.t.u. per lb. mole

$S = -8.4$ B.t.u. per lb. mole per ° abs.

Final conditions, (2)

$P = 3000$ lb. per sq. in. abs.

$S = -8.4$ B.t.u. per lb. mole per ° abs.

TABLE I

Construction of an H—S chart for a natural gas having a pseudo-critical temperature of 383° absolute, a pseudo-critical pressure of 664 lb. per sq. in., abs., and a gravity of 0.7

	P=14.7 lb. per sq. in. abs. $P_r = \frac{14.7}{664} = 0.0221$					P=1000 lb. per sq. in. abs. $P_r = \frac{1000}{664} = 1.506$							P=2000 lb. per sq. in. abs. $P_r = \frac{2000}{664} = 3.012$					
°F.	T in °abs. = (°F.+ 460)	$T_r = \frac{T}{383}$	H B.t.u. per mole	S B.t.u. per mole per °abs.	Fig. 2 $\frac{-\Delta H}{T}$ B.t.u. per mole per °abs.	Fig. 2 $\frac{-\Delta H}{T}$ B.t.u. per mole per °abs.	$+\Delta \frac{\Delta H}{T}$ B.t.u. per mole per °abs.	$+\Delta H$ B.t.u. per mole	Fig. 3 $+\Delta S$ B.t.u. per mole per °abs.	H B.t.u. per mole	S B.t.u. per mole per °abs.	Fig. 2 $\frac{-\Delta H}{T}$ B.t.u. per mole per °abs.	$+\Delta \frac{\Delta H}{T}$ B.t.u. per mole per °abs.	$+ I$ B.t.u. per mole	Fig. 3 $+\Delta S$ B.t.u. per mole per °abs.	H B.t.u. per mole	S B.t.u. per mole per °abs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) (7)—(6)	(9) (8)+(2)	(10)	(11) (4)+(9)	(12) (5)+(10)	(13)	(14) (13)—(6)	(15) (14)×(2)	(16)	(17) (4)+(15)	(18) (5)+(16)
32	492	1.285	0	0	0.021	1.92	—1.90	—935	—9.73	— 937	—9.73	3.64	—3.62	—1781	—12.36	—1781	—12.36
100	560	1.462	675	1.285	0.014	1.125	—1.111	—622	—9.12	+ 53	—7.83	2.30	—2.29	—1282	—11.37	— 607	—10.08
200	660	1.723	1740	3.03	0.009	0.681	—0.672	—444	—8.85	1296	—5.82	1.30	—1.29	— 851	—10.70	+ 889	— 7.67
300	760	1.984	2895	4.67	0.005	0.461	—0.456	—347	—8.70	2548	—4.03	0.848	—0.843	— 641	—10.41	+2254	— 5.74
400	860	2.245	4150	6.21	0.004	0.318	—0.314	—270	—8.62	3880	—2.41	0.575	—0.571	— 491	—10.25	+3659	— 4.04

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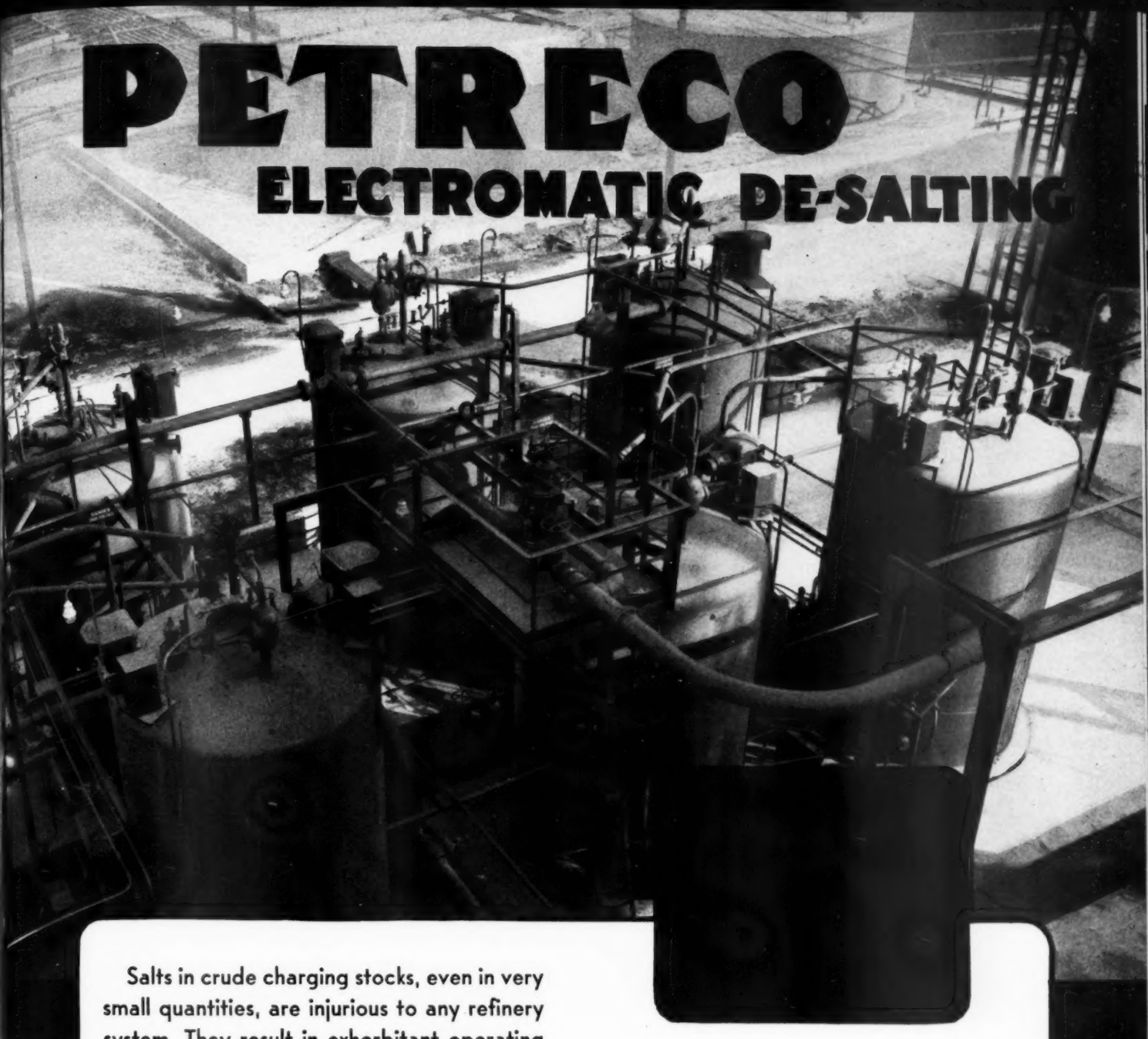

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DE-SALTING DEHYDRATING

By following the constant entropy line of —8.4 vertically from the initial conditions until it intersects the 3000 lb. per sq. in. abs. pressure line, the final temperature is read as 221°F. and the enthalpy as 870 B.t.u. per lb. mole. Work of compression $= \Delta H = H_2 - H_1 = 870 - (-100) = 970$ B.t.u. per lb. mole

$$\text{Indicated hp.} = \frac{970 \times 107.7}{2545} = 41.0$$

Using an efficiency of 85 percent for the compressor:

$$\text{Brake hp.} = \frac{41.0}{0.85} = 48.2$$

Acknowledgments

The heat capacity chart (Fig. 4) was prepared by Dr. D. L. Katz. The H — S diagram, Fig. 5, was constructed by George H. Hanson.

Nomenclature

f = fugacity, lb. per sq. in. abs.
f^* = fugacity at a pressure so low that $f = P$
$F = H - TS$
H = enthalpy, B.t.u. per lb. mole
T = temperature in degrees Rankine, (°F. + 460)
T_c = molal average, or pseudo-critical temperature (°F. + 460)
T_r = pseudo-reduced temperature
S = entropy, B.t.u. per lb. mole per ° abs.
P = pressure, lb. per sq. in. abs.
P_c = molal average, or pseudo-critical pressure, lb. per. sq. in. abs.
P_r = pseudo-reduced pressure
R = gas constant, 1.987 B.t.u. per lb. mole per ° abs.
V = specific volume, cu. ft. per lb.
$Z = \frac{PV}{RT}$, compressibility factor
C_p = heat capacity at constant pressure

P 732.3
P 732.7

Chart For Determining Linear Expansion in Ferrous and Non-Ferrous Metals

by W. F. Schaphorst

THE accompanying chart tells, in a rapid and simple manner, the number of inches expansion in any metal from mild steel to bronze. It is applicable for any length of any metal, from 20 ft. to 10,000 ft. (See Column A).

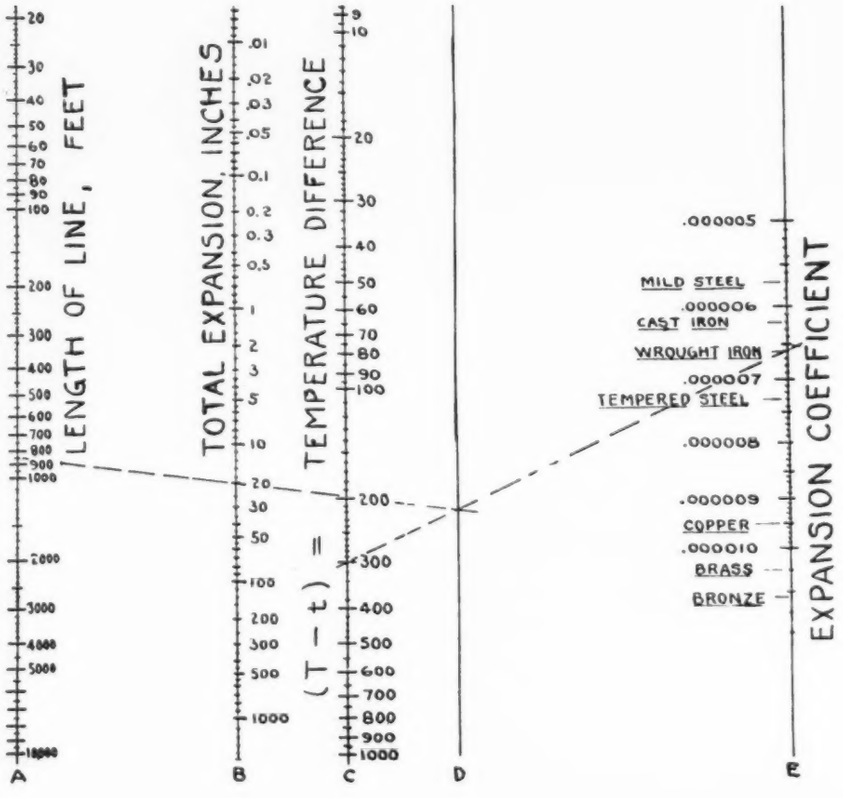
For example: How much will 850 ft. of wrought iron pipe expand during an increase in temperature of 300° F.?

Solution: Connect the 300 (Column C) with the coefficient of expansion of wrought iron (Column E) and locate the intersection with Column D. Then, from that point of intersection run over to 850 (Column A), and the expansion is found to be 20 in. (Column B).

So, all one has to do is to lay a straight edge across the chart a couple of times and the total expansion in inches is determined without bothering one whit with the decimal point. If you haven't a straight edge use a thread, a straight piece of paper, or anything else that is convenient and straight.

It will be noted that this chart can be used for "any material" having a coefficient of expansion between 0.000005 and 0.000012.

The coefficients of the principal metals that fall between those limits are indicated on the chart.



The temperature difference (T—t) is found by subtracting the minimum temperature from the maximum. Thus a steam pipe at its coldest may be 40° F. At its hottest it may be 740° F. The difference is, therefore, 740 — 40 = 700° F.

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Probability Theory Applied to Oil Exploitation Ventures

PART 3

by Sylvain J. Pirson, Associate Professor of Petroleum and Natural Gas Engineering, The Pennsylvania State College

A photograph and biographical sketch of the writer can be found on page 27 of the February issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

Application to Wildcat Lands

In valuation of oil and gas properties, the engineer is often confronted with the problem of estimating the value of wildcat lands when scientific information of some sort may or may not be available and also of evaluating the discount that should be allowed for taking care of certain economic, political, or social hazards in the operation of an existing enterprise. The problem is essentially one of gambling in a safe manner in such a way that the gambler's available capital will not be exhausted by the possible failure of some of the enterprises. For every chance in a venture that a gambler takes, whether he be a wildcatter or a speculator purchasing a hazardous enterprise such as oil production, there exists a fair price above which figure he should not purchase. This price depends on the purchaser's available funds as well as on the probability of occurrence of hazards to the venture he is considering. The principle of safe gambling, which a wildcatter must necessarily observe if he wishes to stay in business, consists in investing a sum in the drilling venture that should not be so large that, in case of an unsuccessful well, he will not have enough money to drill a second well, and should this second one be dry, he should have enough money to repeat a similar operation a third time, and so on until he will finally discover a new field that will repay him for his previous failures. In other words, the law of averages will play a part to the extent that he will, in the end, discover enough oil to either make a profit, break even, or sustain a loss. If he is able, however, to estimate with a sufficient degree of precision the probability of the successful occurrence of the ventures into which he enters and if he restricts his investment to a sum smaller than a certain break-even price commensurate with the probability of the event as well as with his available capital, he can not fail, in the end, to make a profit.

The above reasoning can be verified by the following mathematical considerations: There are m tickets in a lottery for one single reward R. Determine what price should be paid for a ticket by a gambler whose available capital is n times larger than the reward R so that by repeated gambling at a lottery with identical odds an average number of gains may balance an average number of losses.

After an unsuccessful drawing of the lottery he has $\left(nR - \frac{xR}{m}\right) = nR\left(1 - \frac{x}{mn}\right)$ available capital, if he pays the sum of $\frac{xR}{m}$ for one ticket. After a successful drawing of the lottery, his available capital becomes $nR - \frac{xR}{m} + R$ or $nR\left(1 - \frac{x}{mn} + \frac{1}{n}\right)$. After each loss, therefore, his capital is multiplied by $\left(1 - \frac{x}{mn}\right)$ and after each gain by $\left(1 - \frac{x}{mn} + \frac{1}{n}\right)$. But losses and gains are not equally probable; for a large number of drawings of the lottery, on the average only one will be successful and $m - 1$ will be failures. For the gains to balance the losses in the long run, therefore, the product of the capital reductions sustained in an average number of losses multiplied by the capital increases in an average number of gains must equal unity. Therefore:

$$\left(1 - \frac{x}{mn}\right)^{m-1}\left(1 - \frac{x}{mn} + \frac{1}{n}\right) = 1 \quad . . . . . (8)$$

which may be written as follows:

$$1 - \frac{x}{mn} + \frac{1}{n} = \left(1 - \frac{x}{mn}\right)^{-(m-1)} \quad . . . . . (9)$$

and developing the second member of equation (9) into a series by the binominal theorem, we obtain:

$$1 - \frac{x}{mn} + \frac{1}{n} = 1 + (m-1)\frac{x}{mn} + \frac{(m-1)\,m}{2!}\cdot\frac{x^2}{m^2n^2} + \frac{(m-1)\,m\,(m+1)}{3!}\cdot\frac{x^3}{m^3n^3} + \ldots$$

or: . . . . (10)

$$1 - \frac{x}{mn} + \frac{1}{n} = 1 + \left(\frac{m-1}{mn}\right)\frac{x}{n} + \frac{m-1}{2!\,m}\left(\frac{x}{n}\right)^2 + \frac{(m-1)\,(m+1)}{3!\,m^2}\left(\frac{x}{n}\right)^3 + \ldots\ldots$$

. . . . . (11)

If a gambler is to be able to repeat his play a sufficient number of times so that losses and gains will compensate, he must only risk a small fraction x of his available capital nR each time; therefore, in equation (11) x is small compared to n and the terms in $\left(\frac{x}{n}\right)^3$ and higher order will be neglected giving:

$$1 - \frac{x}{mn} + \frac{1}{n} = 1 + (m-1)\frac{x}{mn} + \frac{m-1}{2m}\cdot\frac{x^2}{n} \quad . . . . (12)$$

which can be reduced, after simplication, to:

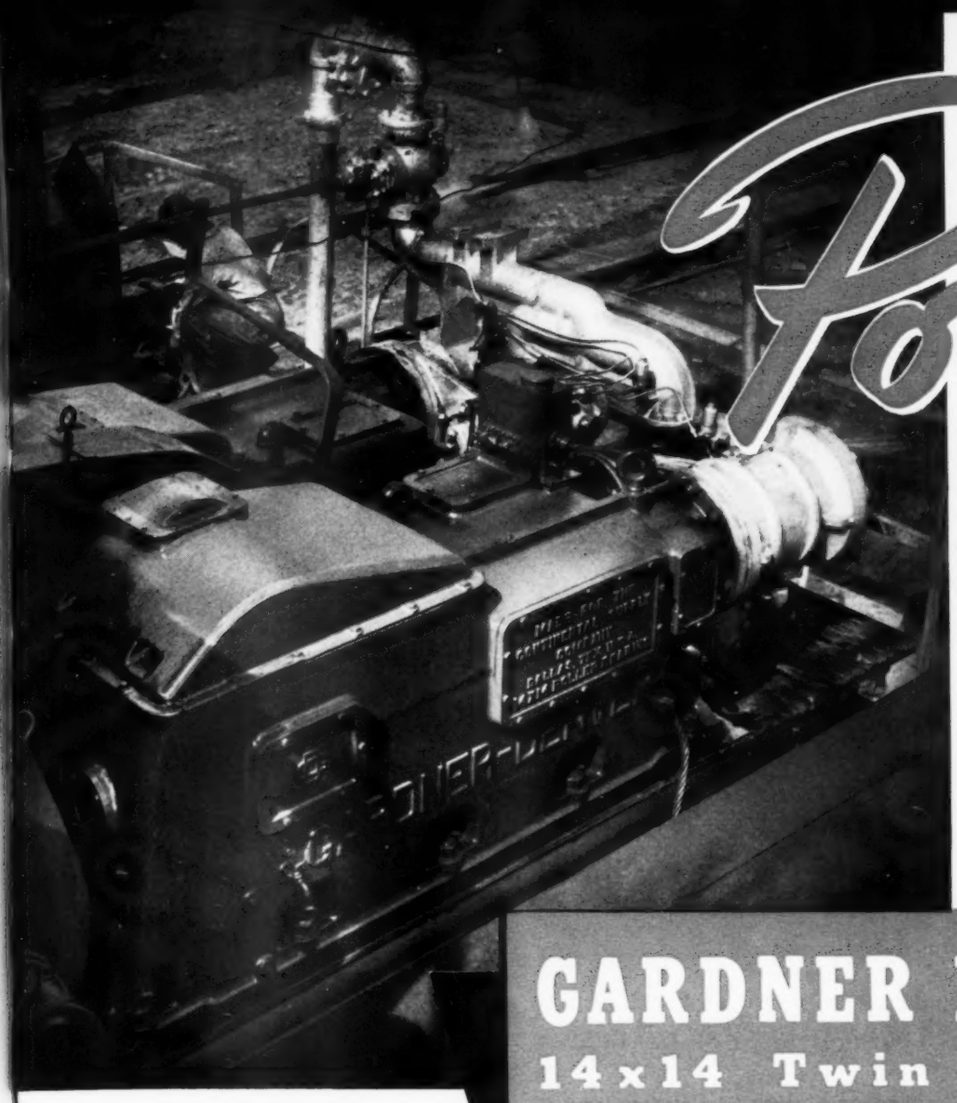
$$\frac{m-1}{2mn}x^2 + x - 1 = 0 \quad . . (13)$$

The solution of this equation yields, by a well-known theorem of algebra:

$$x = \frac{mn}{m-1}\left[-1 \pm \sqrt{1 + \frac{2(m-1)}{mn}}\right] \quad . . . . . (14)$$

Obviously, as x cannot be negative, the minus sign before the square root must be discarded in equation (14). The radical itself can be expanded by the binominal theorem according to:

$$\left[1 + \frac{2(m-1)}{mn}\right]^{1/2} = 1 + \tfrac{1}{2} \times \frac{2(m-1)}{mn} + \frac{\tfrac{1}{2}\,(\tfrac{1}{2}-1)}{2!}\left[\frac{2(m-1)}{mn}\right]^2 + \ldots\ldots \quad . . (15)$$



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and neglecting the terms of the third order, we have:

$$\left[1+\frac{2\,(m-1)}{mn}\right]^{1/2}=1+\frac{m-1}{mn}-\tfrac{1}{2}\frac{(m-1)^2}{m^2n^2}\quad .\ .\ .\ .\ .\ (16)$$

and introducing the value of the radical as obtained in (16) into equation (14) we obtain:

$$x=\frac{mn}{m-1}\left[-1+1+\frac{m-1}{mn}-\frac{1}{2}\frac{(m-1)^2}{m^2n^2}\right]$$

or

$$x=1-\frac{m-1}{2mn}\quad .\ .\ .\ .\ (17)$$

The price that the speculator should pay, therefore, for a chance at receiving reward R, where the probability of receiving said reward is $1/m$, is $\left(1-\frac{m-1}{2mn}\right)\frac{R}{m}$ if he disposes of a capital nR. This sum is the break-even price or the sum that he can repeatedly stake for a chance at reward R when the odds of winning remain the same. In the long run, he will neither lose nor win. If the speculator wishes to make a profit in the long run, therefore, he must pay a price lower than the fraction given in equation (17).

Example 11: A speculator considers buying a royalty under a 40-acre lease, on which a wildcat well is about to begin. The well has been located geologically. If the well becomes a producer it is estimated that the present value of the royalty is $1000 per acre. What is the break-even price that the speculator could give if he had:

(*a*) infinitely large available funds
(*b*) $100,000
(*c*) $1,000,000.

Assuming that the probabilities of discovery are according to those given in Table 1, the probability of a discovery is:

$$1-\frac{9}{10}\times\frac{24}{25}=\frac{17}{125}$$

or 0.136 as geology and random drilling both would play a part in discovering a producer. The break-even price to a speculator with unlimited funds is the mathematical value of the expectation as defined in Rule 5, which yields $40\times\$1000\times\frac{17}{125}=\$5440$.

As the reward to be received by the speculator is valued at $40,000 presently, the coefficient n in equation (17) assumes the value of 2.5 in case *b* and 25 in case *c*. As the problem is analogous to the case of a lottery in which the speculator would hold 17 tickets out of 125, the breakeven price that he should give, when his available capital is $100,000, is:

$$\left(1-\frac{\frac{125}{17}-1}{2\times\frac{125}{17}\times 2.5}\right)\frac{40{,}000}{\frac{125}{17}}=\$4499$$

If the available capital is $1,000,000, the break-even price becomes:

$$\left(1-\frac{\frac{125}{17}-1}{2\times\frac{125}{17}\times 25}\right)\times\frac{40{,}000}{\frac{125}{17}}=\$5346$$

This example shows clearly that the break-even price increases as the speculator's funds are increasing.

A disadvantage of equation (17) is that it cannot be used when the speculator's funds are small. To derive a formula suitable for calculating the sum that a speculator with small means can safely invest in a venture a new approximation must be sought.

Let us suppose that a speculator with available funds of $n wishes to invest in a series of ventures paying respectively a reward R_1, R_2, R_3,...and that the probabilities of receiving said rewards are respectively p_1, p_2, p_3,... What is the sum x that can be safely invested to break even in the long run?

A rigorous answer to this question requires that the product of the fractional increases contributed to his capital by each of the rewards is equal to unity. This is obtained as follows:

Supposing that the speculator wins R_1. After paying a sum x for the chance, his capital becomes $(n+R_1-x)$ and the fractional increase is $1+\left(\frac{R_1}{n}-\frac{x}{n}\right)$. But he has only a chance p_1 of obtaining the reward. Therefore, his probable fractional increase of funds by the possibility of receiving the first reward is:

$$\left(1+\frac{R_1}{n}-\frac{x}{n}\right)^{p_1}\quad .\ .\ .\ .\ (18)$$

For the other possible rewards, therefore, we have a similar expression, bearing in mind that some of the rewards may be zero. As we have assumed there will be no increase in the available funds of the speculator, we have:

$$\left(1+\frac{R_1}{n}-\frac{x}{n}\right)^{p_1}\left(1+\frac{R_1}{n}-\frac{x}{n}\right)^{p_2}\ .\ .\ .=1.\ .\ .\ .\ .\ .\ (19)$$

As it is necessary to speculate a large number of times in order to distribute the risk, the price paid, x, must necessarily be small compared to n. Consequently, we shall change the value of each factor of (19) very little if we substitute

$$\frac{x}{n+R}+\frac{xR}{(n+R)n}$$

for the value $\frac{x}{n}$. We obtain:

$$\left(1+\frac{R_1}{n}-\frac{x}{n+R_1}-\frac{x\,R_1}{(n+R_1)\,n}\right)^{p_1}\left(1+\frac{R_2}{n}-\frac{x}{n+R_2}-\frac{xR_2}{(n+R_2)\,n}\right)^{p_2}\ .\ .\ .=1.\ .\ .\ (20)$$

which may also be written in the following way:

$$\left(1+\frac{R_1}{n}\right)^{p_1}\left(1-\frac{x}{n+R}\right)^{p_1}\left(1+\frac{R_2}{n}\right)^{p_2}\left(1-\frac{x}{n+R}\right)^{p_2}\ .\ .\ .=1.\ .\ .\ (21)$$

or:

$$\left(1+\frac{R_1}{n}\right)^{p_1}\left(1+\frac{R_2}{n}\right)^{p_2}\ .\ .\ .=\left(1-\frac{x}{n+R_1}\right)^{-p_1}\left(1-\frac{x}{n+R_2}\right)^{-p_2}\ .\ .\ .\quad .\ .\ .\ .\ (22)$$

Making use of the fact that x is small compared to n each one of the factors of the second member of equation (22) can be developed into a series by the binominal theorem, and neglecting the terms of higher order than the first, we have:

$$\left(1+\frac{R_1}{n}\right)^{p_1}\left(1+\frac{R_2}{n}\right)^{p_2}\ .\ .\ .=1+x\left(\frac{p_1}{n+R_1}+\frac{p_2}{n+R_2}+\ .\ .\ .\right)\quad (23)$$

from which the value of x can be derived as follows:

$$x=\frac{\left(1+\frac{R_1}{n}\right)^{p_1}\left(1+\frac{R_2}{n}\right)^{p_2}\ .\ .\ .-1}{\frac{p_1}{n+R_1}+\frac{p_2}{n+R_2}+\ .\ .\ .}\quad .\ .\ .\ .\ .\ .\ .\ .\ .\ (24)$$

It must be remarked that equation (24) can be applied when one or several of the rewards are zero. In particular if there is only one reward R whose probability of occurrence is p, the probability of receiving no reward is $1-p$ and applying equation (24) where $R_1=R$; $R_2=0$; $p_1=p$, and $p_2=1-p$:
we have:

$$x=\frac{\left(1+\frac{R}{n}\right)^{p}\left(1+0\right)^{1-p}-1}{\frac{p}{n+R}+\frac{1-p}{n+0}}\quad .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ (25)$$

or:

$$x=\frac{n(n+R)}{n+(1-p)R}\left[\left(1+\frac{R}{n}\right)^{p}-1\right]\quad .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ (26)$$

Equation (26) is a very useful relationship in valuation of wildcat lands particularly to those speculators with little means because at no time during its derivation was it assumed that the available funds n were large compared with the reward R.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer*.

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A Functional Analysis of the Engineer's Place in the Petroleum Industry

PART 2

by E. N. Kemler, Associate Professor of Mechanical Engineering, Purdue University

THE specific duties of an engineer in any of the various capacities in which he may be called upon to serve will depend on whether he is in a supervisory capacity or actually engaged in carrying out specific duties. In the case of a small organization the amount of supervising work required is at a minimum and the duties become very nearly those of the field group in a large organization.

In Part 1[1] the duties of a mechanical engineer were outlined in Table 1. In Tables 2 to 4, presented herewith, are outlined the duties of the petroleum, chemical, and civil engineers, respectively.

In a large organization the central office should be primarily concerned with the establishment of general policies and practices. They must necessarily check information and work done by the field engineers to see that it represents best practices and is in accordance with company policies. The central office is also responsible for checking practices between various divisions and in seeing that those new ideas or practices developed in one division are disseminated to all other divisions. The central office group should likewise carry out special investigations that require extensive experimental work, special instruments, specially trained or experienced men, or which will require extra personnel over a reasonably short period of time. In handling the work in this manner the field organization will be able to go ahead with its normal duties, many of which must necessarily be performed at one proper time to give the maximum benefits.

The engineer in the field is primarily concerned with getting things done. The nature and manner of oil-field operations require than many things be done immediately and consequently snap judgment must be used in spite of the fact that if more time for analysis and investigation were available, the job might be done much better and perhaps at a lower cost. In considering the more detailed discussion of the organization manual, the distinction between these two types of jobs should be carefully considered.

[1]See *The Petroleum Engineer*, p. 27, March, 1941, issue.

Mechanical Engineer

A. Drilling. In considering engineering activities the various functions have been divided among the different fields of engineering. This division has been made because of its acceptance by the industry rather than because of its indication that one so-called kind of engineer can do the work while another cannot. As a matter of fact an engineer in a small company may be called on to perform all the functions that will be listed, regardless of his training. The training that an engineer gets in school is only a beginning and unless he carries this on by further study and experience he will not amount to much as an engineer regardless of the course he took or how high his grades were in school. A graduate from any of the branches of engineering can, with reasonable effort and study, succeed equally as well under such conditions as if he had taken any other course. It may take him a little longer to get started under such conditions but over a period of years it is generally a question of the abilities of the man rather than his college training.

A photograph and biographical sketch of the writer can be found on page 27 of the March issue of *The Petroleum Engineer*, in connection with Part 1 of this series.

A complete and detailed discussion of the various engineering activities listed would obviously be impossible in any article of reasonable length. In the discussion that follows the plan will be to consider the more general items in detail and the rest of the items as a group. The first item, listed in Table 1, Design of Casing Programs, is a most important one in that a considerable sum of money is involved. The central office should determine the general casing program that will fit the company's general financial and operating policy. Affecting their decision will be such factors as company policy with regard to cash expenditures at the moment, proration regulations, size or type of pumping equipment to be installed, etc. In many cases these extraneous factors really dictate the casing program. As they are matters of policy or executive control they must necessarily be decided in the central office. This casing program should then be checked by the field to see that it is a practical policy and will not result in unnecessary risks. The field has the responsibility of reporting any changes in mud, cementing, or drilling practices, which might make some other casing practice more desirable or necessary. In determining the casing program the engineering department will have had to contact the executive department on matters of policy, the operating department for operating data such as bit size, drill pipe size, etc., and the geological department for geological data on the formations to be penetrated, together with any information that they might have as to core data that must be obtained and any peculiar local conditions that might influence the casing program. Once the general program has been decided upon there still remains the question of material, grades, designs, weights, etc. Here the purchasing department must be contacted for price and purchasing information. Other than these, the difficult problem of design, safety factors, weight and grade must be studied. After the size, make, and weight of casing have been decided upon, the engineer must know that the casing as received meets his specifications. This inspection may be handled by an engineer, a special department, or the warehouse department, depending on company policy. Inasmuch as proper casing design is so closely tied up with its physical properties, inspection and testing become important functions, particularly in cases where a low factor of safety is or must be used. As a final function in connection with casing design and application the engineer may have the responsibility of determining proper practices in handling and in running casing. Except for seeing that these instructions are properly understood

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and carried out he should have no further responsibilities.

The operating department has the responsibility of seeing that the material is ordered, is on location when needed, is run and handled in accordance with the general instructions or good practices, and that it is properly made up and landed at the correct depth. Some of their responsibilities may be delegated to the purchasing or warehouse, and geological departments, depending on the organization. It is necessary, however, to have a definite policy either written or commonly accepted by practice.

As casing represents the largest item of drilling expense that is subject to control or manipulation it is necessary that it be given careful attention. The use of factors of safety so liberal that one literally cannot make a mistake obviously results in unnecessarily excessive investment. The use of factors of safety designed to fit a financial program may under certain conditions result in physical failures that may be very costly. The design of casing must be carefully considered by a man trained in design and who is competent and capable of analyzing this involved problem. Because of the involved nature of this problem the average field man is not equipped to pass on it. This is in no manner a reflection on his ability but rather is based on the fact that he is generally concerned with so many problems that he does not have sufficient time to investigate properly so complicated a situation. As a matter of fact those who have followed this problem in detail find it complicated and find it difficult to decide on the merits of certain data, theories, manufacturing procedures, and factors of safety. Because of the involved nature of the problem it can be seen that cooperation between men and departments is very necessary for the proper function of any system and the attainment of the maximum benefits of the technical organization.

The foregoing discussion has outlined what the engineer should do with regard to casing. It should be mentioned here that he certainly should not make a practice, as is sometimes done, of witnessing every string of casing run. This is a very important function and one that should be delegated to someone with experience and authority. It is not generally an engineering but rather an operating problem and unless there is something else involved, should be made the responsibility of, and handled by, the operating unit.

In such items as fuel and water supply, the engineering department may have little to do. In cases involving a consideration of the most economical fuel to be used, an engineering survey may be required. After these economics of the problem have been decided, however, it should no longer be an engineering problem. The chemical unit may have to be called upon to determine proper treatment, suitability of various water sources, etc. Such work as making connections, running lines, setting meters, etc., are operating problems and should be handled by the operating unit.

The question of well hookups again requires coöperation between the operating, geological, and engineering units. The prediction of conditions to be encountered, the operating practices to be followed, the type equipment to be used, the drilling objective, and the other requirements to be met in the way of future equipment applications, standards, etc., must be taken into account in designing this hookup. Here again each unit must know its responsibilities and realize that failure to supply accurate or sufficient information may result in later trouble.

Cementing recommendations and specifications can in general be set up as general policies. They must necessarily vary from one district to another because of state regulations, drilling practices, differences in formations to be cemented, etc. Except for certain general policies the field must here have a considerable responsibility. The questions of cement specifications and cementing practices are technical in nature and must be handled in connection with the chemical or testing unit. Once the general policy with regard to the amount of cement to be used or the cementing objective is established, however, and materials and procedure have been decided upon, the matter should then be turned over to the operating unit. Such problems as getting the cementing crew out at the proper time, seeing that materials are on hand, that the proper crew is available, etc., are strictly operating problems and should be handled by the operating units. Once a well is cemented the engineering department may run or have run a temperature survey for future information, to see if their objective has been attained, or to see what changes might be made in their cementing recommendations for that particular field in the future.

TABLE 2

Duties of Petroleum Engineer

Drilling

Mud control
Completion methods
Core analysis
Correlating drilling and geological information
Analysis of electric logs
Drilling recommendations
Exploitation

Production

Well clean-outs
Perforation for production control
Perforation for production
Well plug-backs
Well abandonment
Secondary recovery
Water-flooding
Repressuring
Analysis of reservoir data
Reserves
Water shutoff
Shooting
Acidizing
Pressure maintenance

Coring practices insofar as they are influenced by equipment operation might be investigations by the engineer. His supervision or investigation, however, should be limited to determining proper procedure and equipment. Once these have been determined the actual coring then becomes an operating problem. The time to core and amount of core to take are properly the job of the geologist or exploitation engineer.

The analysis of drilling costs may be considered the problem of the operating unit or if desired may be considered an engineering function. In case there is an engineer or competently trained man in the operating units, the cost analysis may be handled in that unit, except perhaps as cost may influence such engineering functions as casing design or equipment selection. Here again it is not so important as to who shall do the analysis work as it is to know who is responsible for doing this work and what authority he may have for changing certain conditions found to exist. The policy to be followed may depend on whether or not the work is contracted or done with company tools. In any case some definite policy should be followed.

The selection of equipment is definitely an engineering function. New equipment developments and refinements require careful analysis to determine their effect on maintenance and investment charges. In connection with equipment selection, the analysis of operating expenses must be given careful study. Unfortunately final maintenance costs are not available until the equipment is replaced so that selection involves careful comparisons with existing equipment and its operating expense. The tendency of some manufacturers to reduce size or quality to meet price competition requires that a careful analysis of the mechanical design be made. The engineer must then ascertain which of the various designs will best meet the operating unit's requirements.

Of the operating problems only those of an engineering nature should be

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handled by the engineering unit. These problems should be in the nature of special investigations and will in general be special studies to see what operating techniques are necessary to put into effect technical developments, new types of equipment, or new practices. Once the problem has been analyzed and a procedure or technique developed, it should revert to the operating unit for execution. In safety work the engineer should only be concerned with those problems involving equipment selection, design, or application, which will affect the operation of this equipment.

B. Production. Equipment is the most important item with which the mechanical engineer has to deal in connection with production work. The problem of equipment selection is primarily one involving the application of principles of machine design to the evaluation of the capacity of the equipment. In any piece of mechanical equipment it is necessary to check the bearings, beams, gears, chains, etc., to determine their capacity and to determine what loads and horsepower they are capable of transmitting. Once this has been established it may be necessary to check kinematically to see if the machine will perform the function for which it is intended in a satisfactory manner. Once the rating has been established for the machine, it must be studied to see if it meets certain operating requirements. This may include proper lubrication of brake or clutch levers, provision for oil changing, lubrication, etc. Although these features may not affect the physical rating placed on the machine, they may have a very pronounced influence on the service obtained in the field, on the safety with which the equipment may be operated, or on the care that the field men will exercise in operating the equipment. A knowledge of repair work required on various types of equipment and a review of expense in connection with existing equipment is very necessary as a guide in selecting between various types of equipment. Although the compilation of cost data is an accounting problem, and the tabulation of many of the data is a clerical job, the actual analysis is definitely an engineering function. Without engineering training and experience the full benefits of analysis cannot be attained and certainly the full application value cannot be realized unless handled by a competent engineer.

TABLE 3
Duties of Chemical Engineer

Emulsion treating
Treating of fuel oil for oil engines
Salt-water treatment
Water analysis
Treatment of water for camp consumption
Treatment of water for pumping engines, etc.
Paraffin treating
Mud treatment
Gas treatment
Corrosion

The problem of equipment selection is very clearly an engineering problem. The fact that equipment was originally selected by operating men during a period when engineers were not generally employed in production work does not warrant continuation of this policy. Certainly the operating man without a technical training is not competent to pass on the relative merits of two designs of equipment. In many cases, of course, the job done by these men in the selection of equipment is satisfactory. This will be true if they select equipment made by reliable manufacturers and more specifically if this be the manufacturer's best class of equipment. Because of the competitive nature of the oil business today the operator who gets ahead must take advantage of the very best equipment available. Inasmuch as repair costs continue for the life of the equipment, a small savings per year by selecting a little better design or a type requiring less or cheaper repairs may mean a worthwhile savings during the life of the equipment.

In instances where existing equipment is not adequate, where refinements in equipment are desirable, or where special equipment is required, the use of fixed minimum specifications may be necessary. Specifications must be used with due care or they might penalize the purchaser either because they exclude satisfactory stock equipment or because they are not flexible enough to permit taking advantage of new developments. The use of specifications for material such as sucker rods or casing may likewise prove a handicap in that they may require special steels or exclude equal materials as manufactured by some new or different process. Some of these objections can be avoided by revision of specifications. There is always some inertia, however, and frequent revisions may result in lack of respect or regard for the specifications., In cases where specifications are turned over to a purchasing department for use in competitive buying, there is a very definite advantage in keeping the specification as broad as possible. Such buying is generally possible only in case standard or mass-production items are being purchased.

The final selection of a particular item of equipment or a series of sizes will depend on the immediate and future requirements and will be affected by the standardization policy. The many problems of warehousing, volume purchasing, training maintenance men, specialty men, etc., suggest that the list of makes or sizes of equipment be kept at a minimum. This question of standardization requires careful engineering study. Here again the company purchasing policy must be taken into account. For special or large equipment that must meet certain engineering and operating requirements, close coöperation between the purchasing and engineering departments is essential. The evaluation of the equipment is definitely an engineering problem. By close coöperation with the purchasing department, however, it might be possible to make definite savings by writing the specification as broad as possible. The line of equipment standards will therefore be based on the physical rating of the equipment, operating requirements, and standardization policy as covered by company specifications or manufacturers' design.

More important than equipment selection is the problem of equipment application. The application of engineering principles to the determination of equipment requirements can result in large investment savings or the elimination of high repair expense depending on whether a guess would result in too large or too small equipment. The availability of instruments and the development of techniques today make it inexcusable except in a few cases for not selecting, within a small price range, the proper size of equipment. Failure to take advantage of proper methods in determining equipment requirements may be expensive. In view of the relatively low cost of obtaining full information or equipment requirements, the failure of any management to make this an engineering duty is most unwise. The information that the operating department must supply and the facilities that they must provide for the collection of necessary data must be clearly outlined.

TABLE 4
Duties of Civil Engineer

Making well locations
Making land surveys
Making layout surveys
Supervision of construction
Checking of equipment alignment
Drafting
Records of leases and equipment
Maps

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer.*

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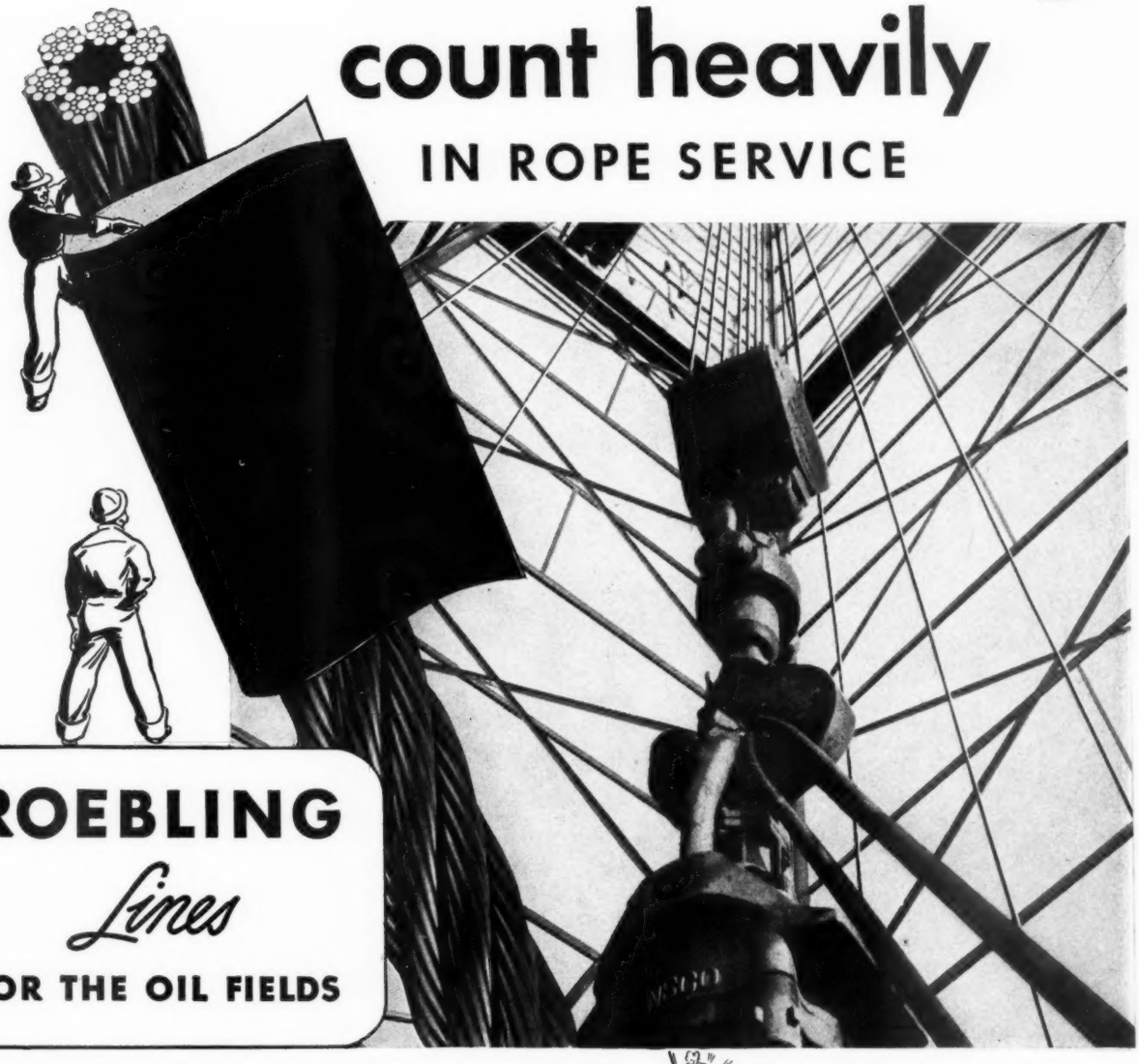

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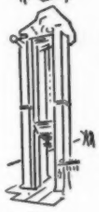

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Gas-Lift in Combination With Other Production Methods

PETROLEUM ENGINEER Exclusive Feature

☆ Comparative data indicate relative efficiencies of various combinations

by S. F. Shaw
Consulting Engineer

S. F. SHAW

received a degree in mining engineering from Columbia University in 1903—From that time until 1926 he was with various mining organizations in Mexico and Costa Rica—While with the American Smelting and Refining Company in Mexico a part of his work involved dewatering of mines by the application of air-lift—This experience and knowledge he later applied to the lifting of oil by air-gas lift methods—Since 1926, during which time he has been connected with various oil companies and has operated as a consulting engineer, he has constantly studied and applied air-gas lift principles to oil production and is considered an authority on the subject—His home is in San Antonio, Texas.

THE simplest and most common type of gas-lift is that of straight, or continuous flow. In the Seminole and Oklahoma City fields, straight gas-lift was followed, first by intermittent flow, after which various combination forms of gas-lift began to be employed for lifting oil from wells in which the flowing pressure had declined to a low value, and yet in which large quantities of oil and water would enter the well bore under these low-pressure conditions.

The earliest instance of combination air-lift of which the writer has any knowledge is that of a combination mine station pump and air-lift, installed to eliminate freezing trouble in the exhaust passages of the pump.[1] "It was not practicable to reheat the air before it was used in the reciprocating pump, which was operating under a 450-ft. head, under air pressure of about 90 pounds. The air working non-expansively in the pump cylinder left the cylinder at approximately 90 pounds. Once mixed with the water, the air acted like an air-lift, forming a mixture in the pump column much lighter than water, expanding in its upward course and assisting in raising the water. The freezing difficulty was effectually overcome."

Three types of combination gas-lift have been employed during the last ten or twelve years as follows:

1. Gas-lift with beam pump or other plunger-pump equipment.
2. Gas-lift with electrical submergible centrifugal pump.
3. Gas-lift with hydraulic pump.

With Plunger Pump

Combination lifting of oil in the Seminole field usually was through the tubing. A packer was set at a convenient point, the tubing was perforated above the packer, and gas passed through the perforations into the tubing. Insufficient trials were made by lifting oil through the casing to determine the efficiency when employing that arrangement. A serious difficulty, however, was the problem of trapping the gas from the formation in the space below the packer, thus making it necessary for all the gas from the formation to pass through the pump, which in itself was a serious objection. Probably the use of two tubing strings would have reduced part, or all this trouble.[2]

The method of using gas-lift in combination with a plunger pump in an oil well was employed in the Seminole field as early as 1928.[3] Three wells were equipped by the Barnsdall Oil Company with this method in the Earlsboro area, that were producing from a depth of about 4300 ft. The casing was 7-in. O.D., and 4-in. tubing was employed as the producing string. The 4-in. tubing was perforated about 1000 ft. above the pump, and gas was admitted to the annular space and entered the tubing through perforations, lifting to the surface the oil that was pumped to the perforations by the plunger pump at the bottom of the well. See Fig. 1 for sketch of this arrangement.

Several wells were equipped by The Carter Oil Company in the Seminole field with the combination gas-lift, plunger-pump method, using 3-in. tubing, and in some instances considerable increases of production were made for a while, but in the course of time, the wearing of long slits in the tubing gave so much trouble that the method was discontinued. That these slits were created may have been due to the prevalence of crooked holes in this field, or to lack of lubrication, or to both. Data on the operation of the combination gas-lift plunger-pump method in the Seminole field are given in Table 1.

In the Carter arrangement of combination plunger-pump method at Seminole, provision in some of the more gassy wells was made for the escape of the formation gas by ripping the producing string at a point below the packer, allowing the gas to escape through the water string. This was effective in reducing gas-lock troubles, but was dangerous in opening the protective string of casing to the producing formation, and would not be followed in general practice. (See Fig. 2.)

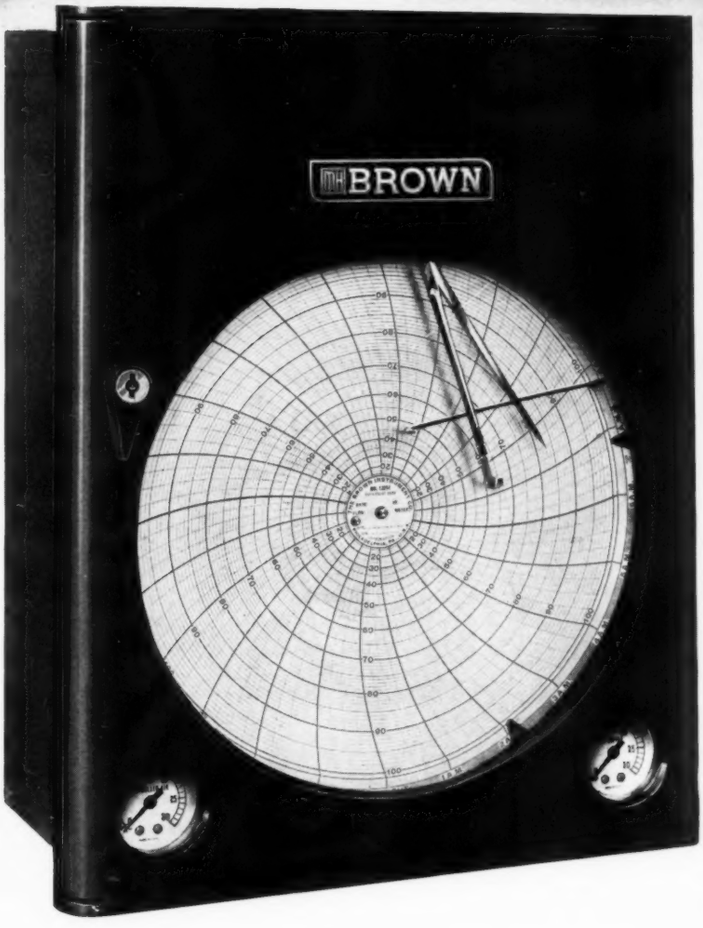
The Jackson pump was tried in a few wells in the Oklahoma City field, and gave some promise of success, and in a few wells seemed to operate fairly successfully for a short period of time. This combination method consisted of a plunger pump run on a tubing string to the bottom of the well. A packer was run on the tubing to seal-off the annular space between the tubing and the casing, at a short distance above the pump. Compressed gas was introduced through the casing and was used to operate the pump. The oil lifted by the pump, together with the exhaust gas that had been employed to drive

[1] *Power*, April 22, 1913.

[2] Shaw, S. F. *Gas-Lift Principles and Practices*. (1939) p. 67. Gulf Publishing Company, Houston, Texas.

[3] "... Combination Pump and Flowing Device Used in Seminole. *National Petroleum News*, November 7, 1928, p. 37.

From PERSIA *to* PALEMBANG *to* PORT ARTHUR



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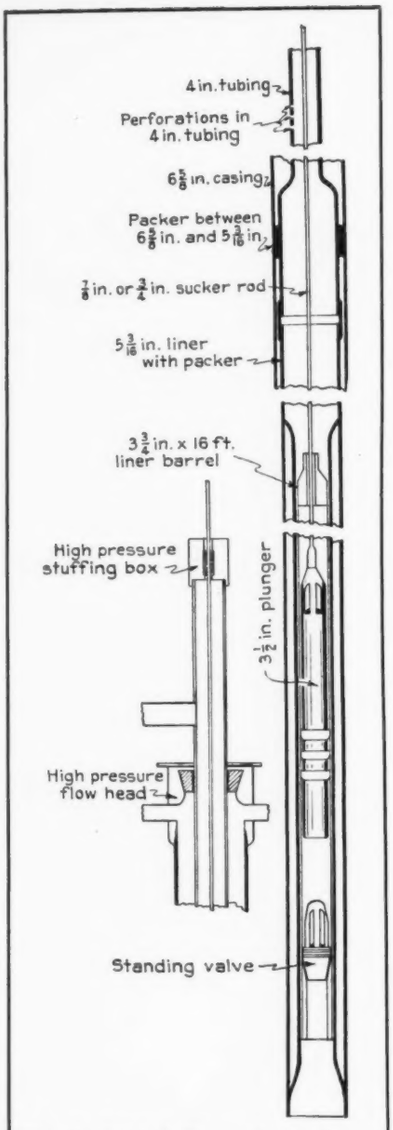
4 in. tubing
Perforations in 4 in. tubing
6⅝ in. casing
Packer between 6⅝ in. and 5 3/16 in.
⅞ in. or ¾ in. sucker rod
5 3/16 in. liner with packer
3¾ in. x 16 ft. liner barrel
High pressure stuffing box
3½ in. plunger
High pressure flow head
Standing valve

Fig. 1. Barnsdall's method of employing gas-lift to lessen the work done by the pump in deep low-pressure wells

the pump, were lifted to the surface through the gas-lift column by means of the gas-lift action of the expanding gas.

It is believed that this type of combination pump has some advantages that justify its being tried out on a more extensive scale, but these trials must have in mind the use of the proper quantity of gas for lifting the oil, which previous tests apparently ignored. Proper sizes of eductors, as well as means for admitting the proper quantity of gas, must be provided, before this pump can be employed successfully.

With Submergible Pump

During the year 1935, the electrical centrifugal pump was introduced into the Oklahoma City field in combination with gas-lift to enable the operators to produce a much higher potential than was possible by straight gas-lift at that period in the life of the field. Also, it was found that the use of this method enabled the oil to be lifted with a much smaller input gas factor than that required with straight gas-lift. This result became possible by reason of the fact that even with very low fluid levels in this field, large fluid volumes would enter the wells, and the problem became one of lifting all or as much as possible of the oil that would enter the well through a pipe of comparatively small diameter from a depth of 6500 ft. Wells that were making 500 to 1000 bbl. per day on straight gas-lift (the method employed at that time for lifting the largest possible quantity from this depth) were increased to as much as 5000 bbl. per day.

In the centrifugal-pump and gas-lift combination method, the pump was run on the lower end of a 2½-in. or 3-in. tubing string with a packer set at a convenient distance above the pump, this distance ranging from a few hundred ft. to as much as 1500 ft. See Fig. 3 for sketch of the arrangements used with the gas-lift, centrifugal-pump combination method.

As a rule, the shorter the distance between the pump and the packer, the greater was the capacity of this type of combination method. In wells, however, with small casing, that is, 6⅝-in. or 7-in. O.D., the friction loss in lifting the oil by gas-lift through the long string of casing offset to a certain extent the reduction of the pressure head against the pump. There was an optimum balance to be reached, therefore, between the pressure head that was imposed against the pump by setting the packer high in the well, as against the pressure set up in the casing by reason of a high lift for the gas-lift.

The centrifugal-pump, combination method operated to best advantage in wells that had been completed with the casings of larger diameters, which in this field were as large as 9⅝-in. O.D., and in many of these wells with this larger diameter of casing, the tubing was of 3-in. diameter, thus reducing

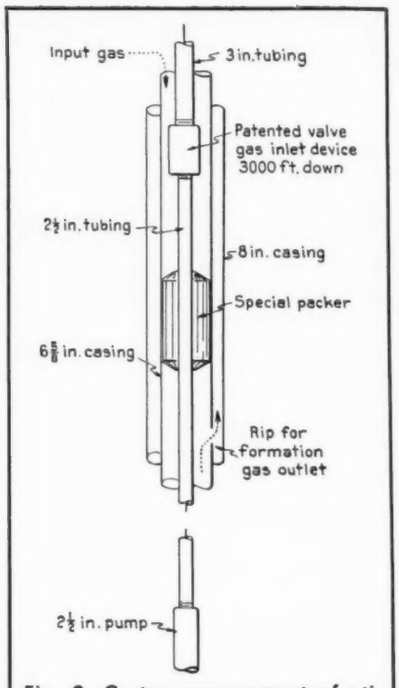

Fig. 2. Carter arrangement of utilizing gas-lift in combination with pumping

the friction loss due to the passage of the gas from the surface to the point where the tubing is perforated above the packer.

The oil picked-up by the centrifugal pump was lifted to a point above the packer where the tubing was perforated, thus allowing the oil to pass into the casing at that point. The compressed gas was pumped down the tubing to these perforations and passed out into the casing, mixing with the oil, and lifting it to the surface.

The centrifugal pump used for this purpose was 10 ft. 8 in. in length, and of 5-in. diameter, and the motor was 20 ft. 9 in. in length and of 5½-in. diameter, with a capacity of 97½ hp. A protector, 4 ft. 10 in. in length, is inserted between the motor and the pump. An armored cable clamped at intervals of about 15 ft. to the tubing and passed through a fluid-tight opening in the packer, conveyed the electric power to the motor. Owing to the space occupied by the upset couplings, together with the cable passing over these couplings, it was not good

TABLE I.

Data on combination gas-lift, plunger-pump method at Seminole

Well	Casing diameter in. O.D.	Tubing		Bbl. oil per day	Cu. ft. gas per bbl. of oil		
		Diameter, in.	Length, ft.*		Input	Output	Gas-oil ratio
A	7	3	3000	177	5024	5965	941
B	7	3	3000	303	3234	5116	1882
C	7	3	3000	500	1255	1644	409
D	7	3	3000	589	1609	2354	745
E	7	3	3000	368	1905	2350	445

*Length of tubing refers to the effective length of eductor column.

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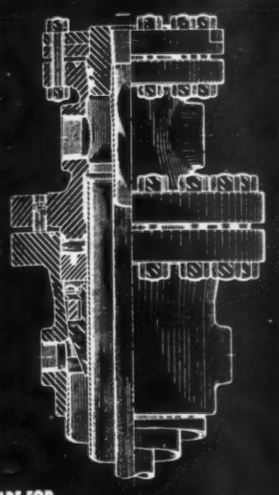

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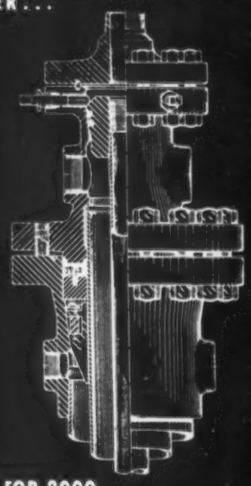
Interchangeable tubing hangers are available for various production practices. Flanges are made to API specifications. Flanged auxiliary control equipment for running tubing under pressure can be attached to tubing hanger spool.

TYPE AF NATIONAL CASING HEAD WITH TYPE FF SET SCREW ANCHOR TUBING HANGER . . .



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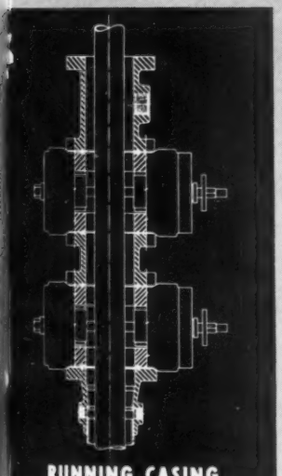
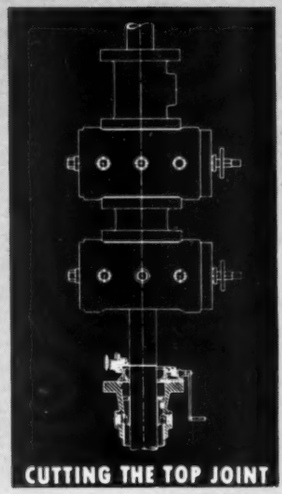


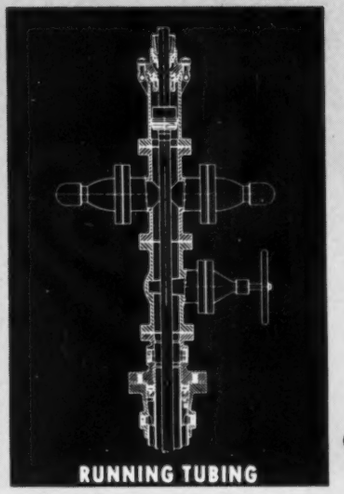
RUNNING CASING

The Blowout Preventers are attached to the casing flange when the outer string is landed. The equipment remains in place until after the oil string has been run.



CUTTING THE TOP JOINT

Blowout Preventers are raised a minimum of 12 inches. Slips are installed in casing flange. Casing Cutter is placed around pipe and bolted to flange, as shown.



RUNNING TUBING

The Tubing Hanger Spool is bolted to the casing flange with Neoprene packing in place. Stripper control assembly is shown attached to upper flange for drilling in and running tubing under pressure.

By the use of the NATIONAL Type A Casing Cutter, casing can be set with the desired amount of tension and cut off without delay. These cutters are available for all Types AL and AF Heads.

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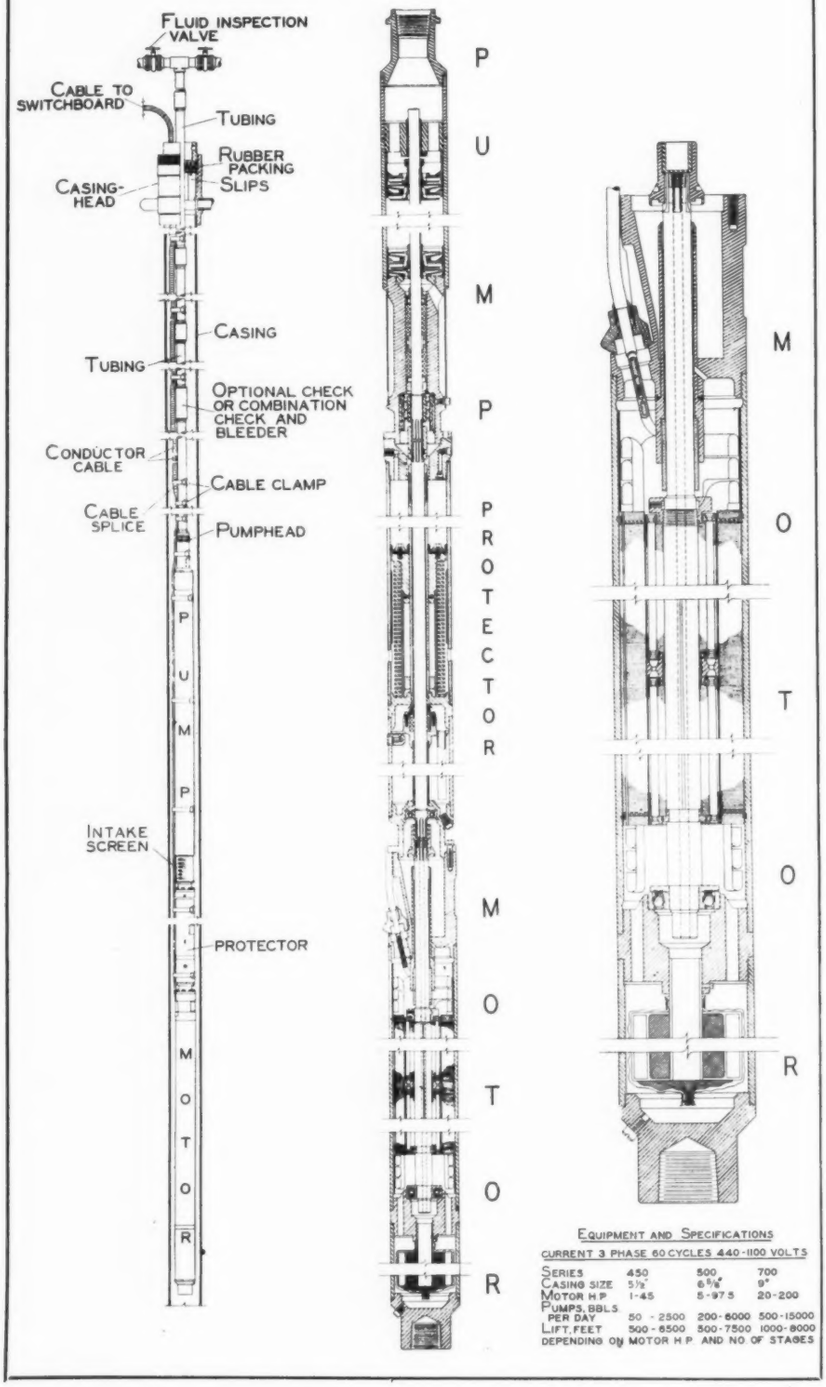
practice to use the combination centrifugal pump method in casings of 6⅝-in. O.D. due to the small clearance, thus causing greater danger of the assembly becoming stuck.

A considerable volume of loose, floating sand accompanied the oil from the formation in wells producing at a high rate of production in the Oklahoma City fields. Consequently there was a tendency for the impellers of the pump to become cut-out, thus reducing the capacity. Also there were occasions when considerable volumes of sand would surge into the pump, thus suspending the action, and making it necessary to pull the pump and send it to the shop for repairs. Nevertheless, rather large quantities of sand were pumped by the centrifugal pump with this method, and the greater production justified the more frequent repairs made necessary by the sand, together with the additional pulling jobs.

Fig. 3. Submergible centrifugal pump of the type often used in connection with gas-lift



In the early life of the field, when much gas accompanied the oil from the formation, it was often found that this combination method could not be employed, and it was necessary to await the time when the gas had declined to the volume where it was feasible to use the pump. During the time when there was considerable formation gas present, however, the straight gas-lift method was operating satisfactorily, and it was unnecessary to use the combination method.

As the use of the centrifugal-pump, combination method occurred at a time when the pressures were low, much trouble was caused by paraffin deposits in the earlier stages of the use of this method, but gradually this difficulty was largely eliminated by the use of a paraffin wash.

This method appears to be especially adaptable to the lifting of large volumes of liquid where the producing horizon is thick and porous, and where flowing pressures and fluid levels are low, and where excessive quantities of gas do not accompany the oil from the reservoir. Data on the use of the gas-lift, centrifugal-pump combination method employed in wells in the Oklahoma City field are given in Table 2.[4]

In Table 2, in a general way, it may be noted that the electric current required to lift a barrel of oil with combination centrifugal-pump methods increases as the production declines. A certain number of kw. are required to operate the pump when it is only idling, however, which quantity is greater as the size of the pump is increased. Theoretically, the size of the pump should be reduced as the production declines, which would tend to reduce the consumption of power per barrel lifted, but from a practical standpoint, it was not feasible in the Oklahoma City field to keep different sizes of motors in stock, particularly when the cost for electric power ranged only from 1 to 1½ cents per kw-hr. when using large quantities of power.

The quantity of compressed gas required to lift a barrel of oil with the centrifugal-pump combination method increased as the quantity of oil declined, assuming that the pressure at the perforations remained constant, but it is probable that as the production declined, there was a tendency on the part of the operator to reduce the quantity of input gas, thereby imposing on the pump the duty of maintaining the pressure at the perforations at a higher point than when a larger production was being lifted, thereby increasing the effective submergence, which was made possible by the fact that a 97½-hp. motor was continued

[4]See Reference 2, page 69.

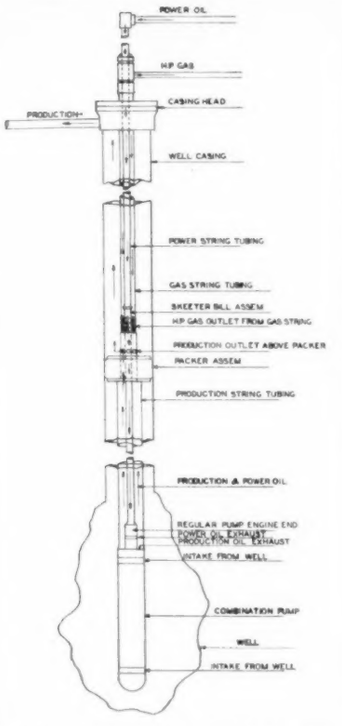


Fig. 4. Installation combining gas-lift and hydraulic pumping

in use that provided ample power for this purpose. With higher submergence, even with smaller daily production, the quantity of gas required to lift the oil from the perforations to the surface would not be much increased. Owing to the fact that the cost of additional gas per barrel of oil lifted, with cost of gas at 8 cents per M. cu. ft., when lifting at reduced rate was in most cases higher than the cost of the additional electric power, there would be a natural tendency to reduce the quantity of input gas close to the point where the well would start to surge heavily, thus placing a heavier duty on the motor of the centrifugal pump. Only by careful tests was it possible definitely to determine the point where the use of increased electrical current would be less expensive than the use of an increased quantity of compressed gas, both of which would depend upon the relative costs of electrical energy and compressed gas.

Gas-Lift with Hydraulic Pump

A few installations of hydraulic pumps in combination with gas-lift have been made in the Oklahoma City field. In this method, the hydraulic pump is run on the lower end of a string of 5-in. casing, with a packer set at about 500 ft. above the pump, and the oil passing through the pump was lifted through this larger pipe to perforations in the pipe above the packer, and then passed into the casing. The oil-producing pump is driven by power-oil pumped by a triplex pump on the surface through a string of 1¼-in. tubing, which is run inside the 3-in. tubing. The gas employed for lifting the oil is admitted at the surface to the annular space between the 3-in. and 1¼-in. tubing strings, passes downward to the power end of the pump, operates the pump, then exhausts into the flow of oil that is pumped from the well, and passes into the casing above the packer. From the perforations above the packer, the oil is lifted by the gas that passes down through the annular space. See Fig. 4 for flow arrangements of pump and pipe in the well. Data that apply to the operation of this combination method are given in Table 3.[5]

In addition to the oil that is drawn from the reservoir the power-oil that is employed for driving the hydraulic pump is lifted to the surface by the gas, but the quantity of this circulated power-oil was not available. If the power-oil were included in the total quantity lifted, the input and output gas factors would be considerably reduced from those given in Table 3.

The wells in which these tests were made were completed with 9-in. casing at a depth of about 6500 ft. in the Wilcox sand.

The hydraulic pump used with the combination method is larger than the usual size of pump. It is run on 250 to 500 ft. of 5-in. casing, and inside the 5-in. casing a string of 1¼-in. power tubing is also run, the two strings of pipe being run simultaneously. A packer of the hydraulic type is then installed on the 5-in. casing, and the entire assembly is then run on the end of a string of 3-in. tubing, with the pump set at a point close to the bottom of the well. The 1¼-in. tubing is then run inside the 3-in. tubing and seated in a shoe in the packer assembly.

From 1000 to 40,000 bbl. of fluid has been lifted between the times when a pulling job is necessary.

This method permits the well to be operated for a considerable length of time by the compressor plant after it has been previously employed for straight gas-lift. Thus far, however, the method has not been employed for a very long period, although the possibilities seem very favorable in certain types of wells where the fluid level does not decline rapidly and where the flow into the well continues at a fairly high rate for a considerable period of time.

The hydraulic pump combination method was rather difficult to install but probably much improvement could be made in the manner of handling the installation to reduce the difficulties. Control of the speed of the pump is maintained from the surface by the quantity of power-oil admitted to the power tubing; it is, therefore, not fixed in speed as is the case with the centrifugal pump. Pulling jobs are often the result of sand trouble, for which reason, the operation would be more favorable in wells making no sand, than in wells where there is a continuous supply of sand entering the well.

[5]See Reference 2, p. 71.

TABLE 2

Data on gas-lift, centrifugal-pump combination method in the Oklahoma City field

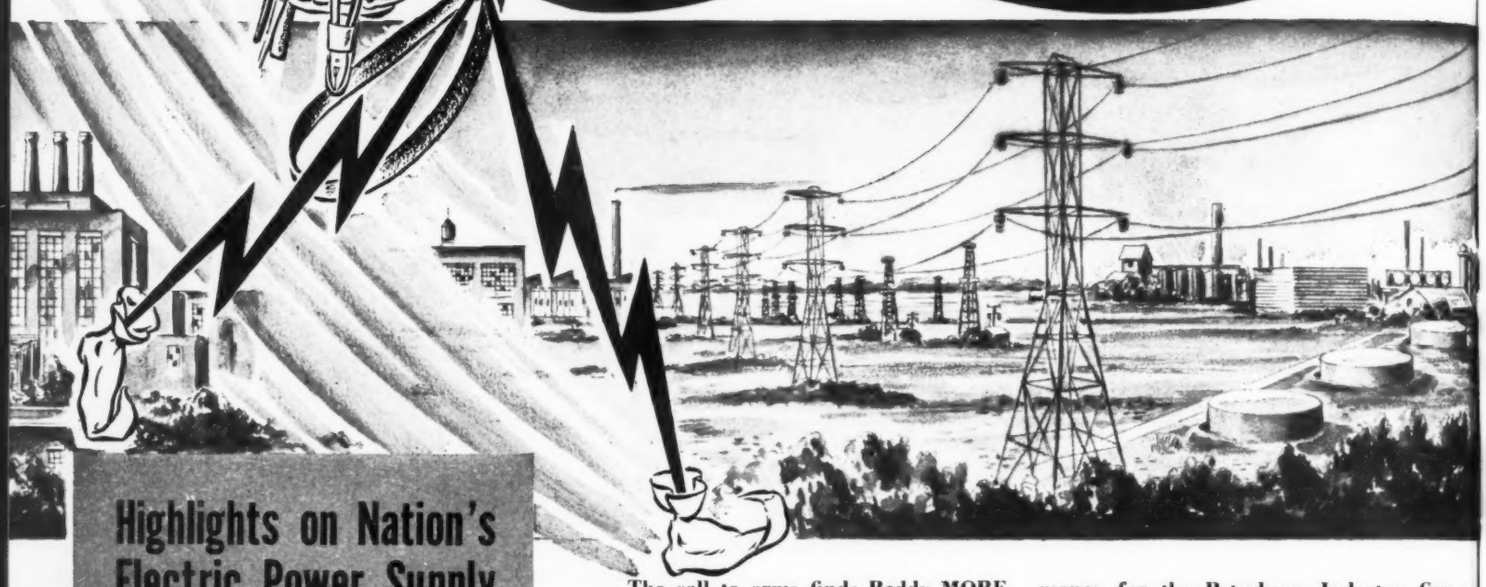
Well No.	Depth, ft.	Barrels per day	Kilowatt hours of current			Volume of input gas		
			Total per day	Total per bbl.	Cost, cents per bbl.	M. cu. ft. per day	Cu. ft. per bbl.	Cost, cents per bbl.
1	6401	4900	2793	0.57	....	5,665,000	1150	1.05
2	6401	4300	2451	0.57	....	5,160,000	1200	1.09
3	6401	4190	2542	0.61	1.19	5,940,000	1490	2.01
4	6401	4000	2120	0.57	....	5,052,000	1260	1.15
5	6401	3690	2616	0.71	1.86	5,000,000	1365	0.67
6	6530	3800	....	....	....	5,040,000	1330	0.74
7	6530	3650	....	....	....	5,406,000	1480	1.04
8	6530	3200	....	....	....	4,500,000	1410	1.50
9	6530	2900	....	....	....	4,222,000	1450	1.37
10	6533	2617	1830	0.70	1.22	4,740,000	1810	1.25
11	6533	2160	2740	1.26	2.16	3,735,000	1810	1.40
12	6533	2110	3250	1.56	2.73	3,550,000	1705	1.70
13	6533	1980	....	....	....	3,985,000	2010	1.90
14	6533	1600	....	....	....	4,059,000	2530	2.41
15	6539	1430	1335	0.92	1.52	3,335,000	2300	2.10
16	6523	1425	3520	2.47	4.30	2,630,000	1815	1.51
17	6623	1390	1870	1.34	2.30	2,870,000	2130	1.53
18	6539	1150	1490	1.34	2.32	3,220,000	2890	2.06

TABLE 3

Data on gas-lift, hydraulic-pump combination method in the Oklahoma City field

Test No.	Bbl. oil per day	Volume of input gas		Volume of output gas	
		cu. ft. per day	cu. ft. per bbl.	cu. ft. per day	cu. ft. per bbl.
1	1727	3,528,000	2043	7,228,000	4185
2	1559	2,646,000	1700	5,946,000	3814
3	1470	2,763,000	1800	3,263,000	2220
4	893	2,334,000	2613	3,108,000	3411

I'M READY TO SERVE MY COUNTRY



Highlights on Nation's Electric Power Supply

- Present utility power generating capacity of all kinds is approximately 42 million kilowatts, or over 4 times that of 1917.
- Over 40 per cent of the above capacity is in excess of the present highest peak load requirements.
- 87 per cent of the total generating capacity is privately owned and operated.
- 72 per cent of the total capacity is represented by steam plants and 28 per cent by water power.
- There are approximately 300,000 circuit miles of high voltage lines of 11,000 volts or higher, comprising a widespread interconnecting electric supply system throughout the nation.
- There are over 275,000 trained and experienced employees of electric light and power companies who stand ready to do their jobs efficiently in any emergency.

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PETROLEUM ELECTRIC POWER ASSOCIATION

Adequate Equipment Records As A Control In Pipe-Line Station Maintenance

PART 2

by H. Lee Flood
Associate Editor

WHEN the failure reports are received in the general office, they are studied thoroughly to determine the cause of the failure and to decide what steps should be taken to prevent a recurrence of the trouble. Sometimes an extended series of tests may be begun as the result of one of these reports. More often and almost invariably each report will only carry a brief notation by the master mechanic in the general office; in the last case cited above, this notation was:

"Leaky exhaust valve gasket was apparently cause of this head failure as this causes excessive heat around area of leak and head failed at this point."

It is perhaps well to emphasize at this point that the material quoted in this article is to illustrate the form of the record rather than for the information itself, which, being disconnected, is, of course, meaningless.

It is also important to note that the methods in use today are the result of trial and error over a period of several years. As in nearly every venture, the finished product wasn't attained in a day. In fact, the procedures are constantly changing and improving and it is hoped they will continue.

As an example of the manner in which progress is made, the system of reporting mechanical failures had only been in effect about a year when it was recognized that it is equally valuable to report incipient failures, i.e., machine parts that may be expected to fail within a reasonably short period of time. Also important is a report of any unusual condition that, although detected before trouble has resulted, might result in a failure elsewhere (at some other station) if not detected.

In the general instructions issued in which the purpose of the failure report was thus expanded, the following actual conditions were cited as examples of the type of information that should be reported:

"Only recently a crosshead bolt was found in the crank case of a 2-cycle engine. Investigation disclosed that the heads of the new style bolt furnished by the manufacturers were undersize and the dowel pins were not long enough to reach the slot in the piston rods. This condition permitted the bolt to loosen up sufficiently for the nut to come off after it had disengaged itself from the locking plate. Eventually the bolt was thrown out of its position into the crank case. After the facts were determined, a thorough check of all of the other engines of the same type was made to determine whether a similar condition might exist. This condition was found in one other of this type engine and was corrected. You can see clearly the value of having such information reported promptly. Fortunately, we learned about this condition on one of the inspection visits to the station where this failure occurred. Even though the failure had occurred several weeks previously, it had not been reported."

"Another example of such information not being promptly reported was the case of loose crank bolt in a_____ engine. Investigation revealed that this condition existed for a number of years and was reported recently only as a matter of conversation. A study of this condition disclosed that the loosening of the bolts resulted from the corrosion of the steel shims between the bottom of the connecting rod and the crank bearing, also between the two halves of the crank bearing. As soon as the cause of this condition was found arrangements were made to replace the steel with brass shims which would correct the condition."

Standard Practices

For several years it has been the policy to issue letters or bulletins of instructions whenever it has been believed necessary to establish a uniform procedure for performing a specific operation. Many companies follow this practice, of course, but it is not believed that they all preserve or continue the value of such letters down through the years. Too often, such correspondence becomes lost in a complicated filing system and is forgotten.

All such procedure letters written within any of the departments of the company are designed as Operating Practices, usually abbreviated as "O P" and each one is assigned a number and a descriptive title that will be a clue to its contents. As these Operating Practices are written and issued, they become a part of the bound volume containing all such memorandums ever issued and are indexed so they may be found readily.

It is only by some such plan that any semblance of uniformity may be obtained when there are so many details to be remembered.

Of the many Operating Practices that have been issued, it is possible here to list only those pertaining to station operations, in order to give an idea of the scope of the subjects covered.

1. Information necessary for shutdown
2. Reporting hourly checks
3. Precautions in handling sour crude
4-6. Engines, precautions in starting (3 circulars)
7. Gathering line, operating, with trunk line stations
8. Coördinating work with pipeline crews
9. Fuel valve trouble
10. Care of pressure-recording gauge charts
11. Obtaining gravity of crude oil
12. Oil losses
13. Field station procedure for shutting down
14. Combustion and mechanical knocks
15. Burning refuse on grounds
16. Hazards of grass fires

17-21. Responsibilities in dispatching oil (5 circulars)

22. Fires and causes of fires
23. Draining to prevent freezing

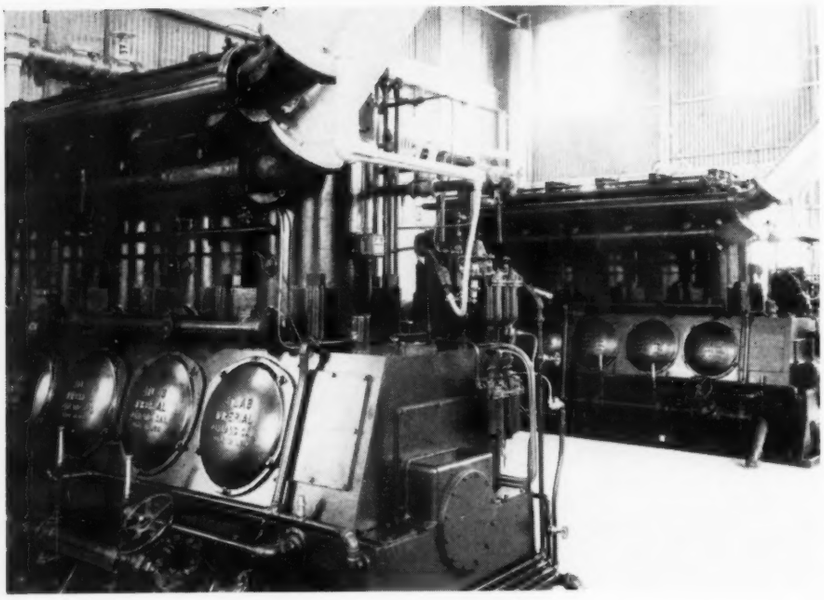
24-27. Smoking (4 circulars)

28-29. Gasoline around stations (2 circulars)

30. Lights in manifolds and junctions
31. Heating of station
32. Starting after shutdowns

33-34. Opening and closing valves under high pressure (2 circulars)

35. Manometers, use of, on tank
36. Shutdown for adjustments or repairs



Diesel engines installed in a modern oil pumping station

37-38. Mechanical failures (2 circulars)
39-40. Engine crankbolts, changing of (2 circulars)
41. Layshaft gears, horizontal engines, adjustment of
42. Crankshaft alignment
43. Cylinder liner rubber rings
44. Grinding nuts on machinery
45. Chairs, safe load limits
46. Gauging
47. Closing suction gates on pumps while discharge gates are open
48. Air tank heads and valves of engines
49. Exhaust valve failures
50. Air compressor cooling coils
51. Nordberg engines, starting of stations with
52. Stations, cold weather starting of field units.
53. Precautions and safe practices in the use of welding equipment
54. Neglect of U-gauges for determining tank gauges
55. Replacement of concrete slabs as covers for muffler pits
56. Replacement of cast-iron crosshead shoes with babbitt-faced shoes on pumps
57. Acid for removal of scale in engine cylinder water jackets, discontinuing the use of
58. Annual inspection and test of air compressor safety valves
59. From station operations, or sleeping on duty, absence of employees
60. Mechanical conditions that might lead to failures, reporting
61. Changing rubber water rings on engine
62. Method of shutting down vertical air injection engines
63. Air compressor regulation
64. Stencil date parts installed
65. Fitting engine piston assembly
66. Pumping unit started against closed valve
67. Crankbolts, tightening of
68-70. Sump tanks (3 circulars)
71. Station employees and linewalker relief
72. Station floors, care of
73. Exhaust conduit
74. Gauge glasses, surge chambers
75. Pipe and conduit in walls and floors
76-79. Annual overhaul notes (4 circulars)
80. Assembling spray valves—air injection engine
81. Diamond floor plate
82-83. Manometer (2 circulars)
84. Pneumercators
85. Engine starting procedure
86. Engine supercharge in cylinder when starting
87. Fitting bronzoid bearings
88. Hand gauges for correcting pneumercators
89. Constant attendance on machinery
90. Plug valves, care of

Summary Ledger

In order to obtain full value from a record of mechanical failures it is essential that a summary be made of all failures that occur in the system. To reduce such seemingly miscellaneous information to statistical form requires that a system be adopted for classifying the failures as to location, type, etc.

In the system now in use, all the so-called statistical data pertaining to mechanical failures are recorded in a large ledger comprising four principal sections:

(1) Summary of failures by stations

(2) Summary of failures by (divisions of) equipment

(3) Details of failures (taken from the individual reports)

(4) Details of future failures (reports of incipient trouble).

The summary of failures by stations serves only to indicate the number of failures (of all kinds) that have been reported by each pump station in the system.

The summary of failures broken down as to equipment is in greater detail. It is from this summary that some of the more valuable results from the mechanical failure records have been obtained. Each make of engine or pump being used in the system is assigned separate space and as failures are reported they are tabulated in accordance with the following classification:

Engines
1. Bearings
2. Cylinder heads
3. Pistons
4. Cylinders or liners
5. Bolts
6. Valves
7. Connecting rods
8. Gears
9. Frames or bed plates
10. Crankshafts
11. Gaskets
12. Miscellaneous

Pumps
1. Bearings
2. Piping
3. Bolts
4. Frames or pump bodies
5. Gears
6. Valves
7. Connecting and piston rods
8. Pinionshafts
9. Plungers
10. Crankshafts
11. Gaskets
12. Miscellaneous

Miscellaneous
1. Piping
2. Gates
3. Gaskets
4. Centrifuges
5. Electric motors
6. Miscellaneous

By turning the pages of this ledger one may readily scan the columns and detect the particular type of equipment that is responsible for the greatest number of failures in the system.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer.*

The writer records data as he makes a test on the mud-testing apparatus before treating a well

PETROLEUM ENGINEER EXCLUSIVE Feature

by Stanley C. Morian
District Engineer,
Dowell Incorporated,
Houston, Texas

Acidizing to Remove Drilling Mud and to Clean-up Sandstone Formations

WHEN acidizing was first introduced to the industry on a commercial basis it was limited to wells producing petroleum from predominantly limestone formations. The desire to develop a chemical service for wells producing from reservoirs composed of sandstones and for wells drilled-in with rotary tools led to the introduction of an acid that facilitates the completion of new wells, recompletions, and workovers. The basic treating material is a chemical solution that is capable of dissolving bentonitic type clays. Other agents such as inhibitors to prevent acid corrosion, stabilized surface tension reducers, emulsion preventers, and wetting agents are added in order to give the treating solution maximum effectiveness.

The theory that oil and gas horizons might be sealed-off by hardened, impervious mud sheaths was advanced many years ago and has since become a commonly accepted idea. In view of these opinions, field work was undertaken to discover chemical methods for removal of the mud sheaths that were thought to be present and retarding the movement of oil and gas from the formation into the well.

As this type of well treating progressed in California and on the Gulf Coast of Texas and Louisiana, using low surface tension acid solutions and dispersing agents, cores of the producing formations, typical drilling fluids, and oil samples were being collected and studied in the laboratories in an effort to learn the effects of various solvent combinations on the physical and chemical characteristics of these materials.

Treating data and other information collected in the field led to the belief that under certain conditions drilling fluids composed mainly of native clay containing certain bentonite-like materials often penetrated the porous, permeable pay horizons during the drilling-in process causing permeability reductions that resulted in abnormally low rates of production and generally inefficient wells. It was found that the dehydrated mud sheaths left on the face of the pay, and water lost in the pay zones, caused serious production problems, especially during the period when the well was being put on production, during the completion, or following workovers.

At the same time laboratory analyses of representative core samples submitted from all parts of the Gulf Coast showed that bentonitic clay was an important constituent of the formation. That bentonitic clay is often an important constituent of the formation is seen in Table 1, which is a laboratory report on the analyses of several cores from typical sand wells.

This table shows that montmorillonite, which is the principal constituent of most bentonitic clays, and kaolin, which is a clay type material, occur to an appreciable extent in sand wells. As the presence of 5 to 20 percent bentonite is considered sufficient to cause plugging, especially after the flush production period when the bottom-hole pressure has declined materially, it is readily seen that any treating that will remove this clay will be

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was born in Bradford, Pennsylvania—Received degree in petroleum engineering at University of Oklahoma in 1934—1934-1937, worked in drilling and production in Western Kansas, New Mexico, West Texas, and Oklahoma—Joined Dowell Incorporated, in March, 1937, as district engineer in West Texas—Went to Gulf Coast for the company early in 1938.

TABLE 1

Laboratory report showing X-ray and solubility analyses of cores from several Gulf Coast wells

Well no.	Depth	X-Ray analysis showing percents of constituents					Percent solubility in:	
		Quartz	Albite	Kaolin	Montmorillonite	Calcite	15% HCl	Mud acid
1	2720 top	75	10	15	..	..	2.4	22.3
	2728	60	25	15	..	..	2.8	27.0
2	2732–37	45	10	..	45	..	12.6	39.8
	2750–51	50	30	..	15	5	4.4	28.1
	2759–60	75	25	..	..	..	2.6	20.4
3	2724–26	55	30	..	15	..	2.0	22.6
	2775–79	45	15	..	30	10	8.3	36.9
	2847–50	55	20	..	25	..	5.5	28.8
4	2754–58	40	15	10	20	15	9.3	33.6
	2758–62	60	20	10	10	..	2.6	21.6
5	2773–79 top	55	10	..	25	10	6.2	28.6
	2773–79 bottom	60	20	..	20	..	5.2	26.0

extremely valuable. It was believed that the same chemicals that would dissolve or disintegrate drilling mud could be used also for dissolving the bentonite-like material occurring in the formation, with resulting increases in permeability and porosity. Accordingly, these problems were approached from the same viewpoint and were worked on simultaneously.

The drilling mud problems were particularly difficult to solve in areas where the producing formations were non-competent and tended to slough or cave unless supported by a heavy mud column during their drilling, and by perforated casing, screens or liners after being drilled. Although these methods were quite capable of preventing caving of the friable formations, they permitted drilling fluid to enter the formation, and the mechanical equipment served to filter out mud, clay, and shale particles that subsequently caused the openings in these devices to become plugged. Scale deposits composed of waxes, various mineral precipitates, mud, and detritus also formed on the equipment causing an additional production problem.

The first measurable success in treating wells producing from sandstones was on the Texas Gulf Coast where wells with pipe set through the producing zones refused to produce after perforation. Chemicals were used successfully to wash out these gun perforations so the wells could produce. Later screens and liners were subjected to washing treatments to remove scale, wax, or mud deposits and accumulations.

The early successes experienced in these washing and cleaning treatments encouraged further and more extensive work along this line. Then mud acid was introduced and "demudding" treatments were advocated. Mud acid is composed of chemicals capable of dissolving and disintegrating practically all types of bentonitic clays such as are used in drilling muds, and also many of the clay-like compounds that are a part of the reservoir rock itself. It also contains surface tension lowering and wetting agents that aid in the removal of water that may have entered the formation from the drilling mud when a well was drilled-in. The surface tension lowering agents chosen specifically for mud acid permit the treating solution to be squeezed into the formation at lower pressures, give better penetration into the minute pore spaces, and effect removal of the reaction products from the formation more easily. Wetting agents and emulsion preventers are selected for each treatment according to the type of crude oil produced from the particular well being treated.

A comparison of the solvent properties of mud acid over 15 percent acid is illustrated in Fig. 1. This figure shows that 1 gal. of mud acid will dissolve one-third of a pound of a typical bentonitic mud, as compared to practically none in 15 percent hydrochloric acid. Most Gulf Coast sands contain appreciable amounts of bentonitic materials, often as much as 20 percent. These sands exhibit quite high solubilities in mud acid as compared to ordinary hydrochloric acid. Table 2 contains solubility data on various producing sands, both in mud acid and in regular 15 percent hydrochloric acid. This table demonstrates very strikingly the effectiveness of mud acid on these formations.

Many of the early treatments were made on unusually difficult wells. As profitable results were obtained in some of these problem wells, however, more and better wells were treated, with constantly improving results.

The success of these mud acid applications stimulated a rapid expansion of the service. The increasing popularity of mud acid service is attested by the fact that more than 300 wells were treated during 1940 in all parts of the country. Table 3 contains some field data from various producing fields showing the results obtained with mud acid.

These results tended to indicate that more was being accomplished than merely cleaning the mechanical equipment at the bottom of the well. It would appear from some of the field results that in addition to cleaning up the screens, liners, and pipe perforations, the treatment had also materially increased the permeability of the formation.

An example of the effect of mud acid on the formation is found in a well producing from 7 ft. of Woodbine sand in the East Texas field. Prior to the mud acid treatment the well produced 113 bbl. per hr. on gas lift with a drawdown of 200 lb. After the treatment this well produced 100 bbl. per hr. on gas lift with a 52-lb. drawdown. Based on these data the permeability of the producing section was about 1550 md. prior to treatment and 4500 md. afterward.

Mud acid has proved particularly beneficial in old wells that have declined to a sub-marginal status. Often the production from such wells declines normally for a long time and then begins to decline abnormally fast indicating that the formation pressure is unable to sustain the normal rate of fluid flow through the formation and into the well. In very old wells produc-

TABLE 2

Mud acid solubilities of various oil-producing sands

State	Pool	Formation	Percent solubility in:	
			15% HCl	Mud acid
Utah	Clay Basin	Dakota	1.2	19.5
Kansas	Albert	Reagan	0.9	8.1
Oklahoma	Cary	Cromwell	5.7	24.5
Texas	Placedo	Frio	3.5	26.2
Louisiana	Charendon	Frio	4.2	43.9
Texas	Aqua Dulce	Frio	24.4	48.3
Pennsylvania	Bradford	Bradford	4.1	15.5
Arkansas	Schuler	Jones	2.1	14.5
Illinois	Griffin	Cypress	1.4	14.5
Indiana	Bufkin	Cypress	0.02	10.5
Oklahoma	Altus	Arkose	15.1	24.9
Texas	Montague	Arkose	5.1	31.5
Wyoming	Frannie	Tensleep	3.8	18.0
Kansas	Russell	Fairport	8.8	13.6
Indiana	Kennsburg	Cypress	3.8	10.7
Colorado	Wilson Creek	Sundance	5.4	29.8
Montana	Cut Bank	Cut Bank	4.7	11.8

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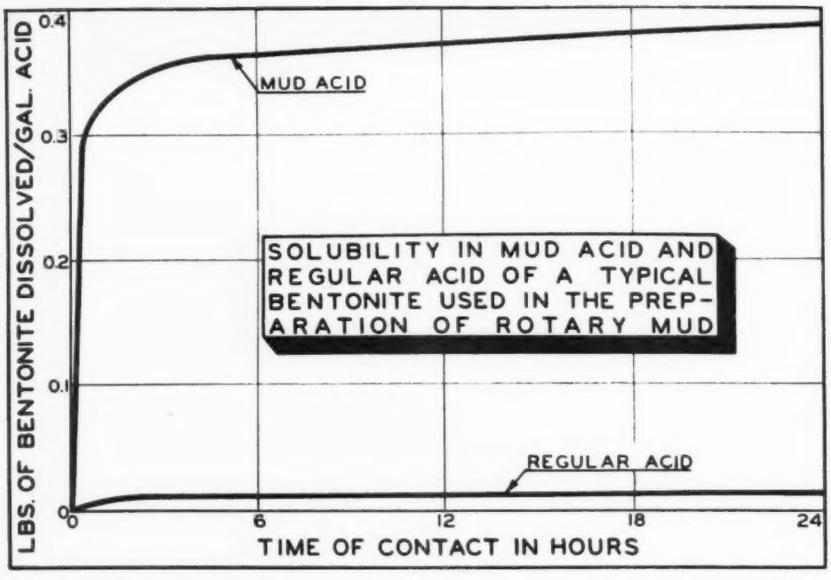

Fig. 1. Comparison of rates at which bentonite is dissolved by acids

ing from formations containing varying percentages of impurities such as clay and shale, it is logical to assume that these impurities have been carried by the oil into the critical zone during the producing life of the well, where they have caused a large decrease in the permeability of the formation. It also seems safe to assume that if the permeability has been greatly reduced because of plugging by these extraneous materials, a large increase in production could be obtained by increasing the permeability. Furthermore, if these plugging materials are not removed, probably the well will be prematurely abandoned, leaving underground a large percentage of the normally expected recoverable oil. By removing these plugging materials, mud acid has given good results in wells of this type.

It is not unusual to increase the production of an old pumping well from 5 bbl. per day to 100 or more bbl. per day by a mud acid treatment. If water is being produced, the oil and water may both be increased but the water-oil ratio is often substantially reduced. A few pumping wells have been made to flow and at the same time the well's potential has been increased, thus decreasing the lifting cost as well as accomplishing the primary purpose of increasing production.

Many sand wells are completed with either a screen or a slotted liner, or perhaps both. This is important in that, first, it provides a well-designed trap for such substances as mud, silt, and shale; and, secondly, it permits the use of acid with no danger of subsequent sanding-up. If there is no such screen or liner, it must be known that the formation is competent and will withstand the effect of mud acid without sloughing or caving into the hole, unless the operator is satisfied increases in production will warrant a clean-out job.

A plugging condition often exists behind screens because of the presence of drilling mud that has been held in place ever since the well's completion. This has been proved by the analysis of samples removed from screens and liners long after well completion. It may be reasonably assumed that the flow of gas and fluid from a very small section of a prolific pay zone might be large enough to camouflage the fact that a great part of the zone remained mudded-off. Removal of the mud sheath late in the life of the well should provide a substantial increase in production as it is at that late period when the bottom-hole pressure has declined seriously that even a very small amount of plugging has its greatest perceptible effect.

The selection of a well, pool, or area producing from a sand formation where mud acid might be used beneficially should be guided largely by: (1) core analysis; (2) initial completion methods, and (3) decline curve behavior.

Wells of the following types are suitable subjects for mud acid treatments:

1. Any well whose core examination shows 10 to 20 percent or more bentonite.
2. Any well surrounded by better producers in the same formation.
3. Any well that has been worked-over using drilling mud or water in the operation.
4. Any well that has been completed recently.
5. Any well making water and oil in certain quantities or ratios.
6. Any well where strainer arrangement is set.

The importance of a clean critical area has been shown mathematically and ties in directly with sand treating. By chemically cleaning that area, not only have great increases in production been obtained, but also the input capacity of gas-cycling or injection wells has been doubled.

In the last year or two cycling operations have assumed a role of importance in high-pressure gas-condensate fields. The injection pressures necessary in order that large volumes of gas may be injected into the intake well in many cases have been in excess of 3000 lb. The horsepower requirements in compressing gas to these high pressures is a very serious problem, so that any method of reducing the high input pressures or of increasing the input volume at constant pressure results in a tremendous saving in horsepower and consequently in operating expense. Mud acid has been used to increase the permeability and porosity of the area near the well bore of gas injection wells, and the results have been outstanding in the degree of success experienced in reducing the input pressures and increasing the capacity of the key wells.

TABLE 3
Mud acid treatment results

State	County	Pool	Formation	Type of completion	Type of well	Gal. acid used	Production in bbl. oil per day	
							Before treatment	After treatment
Louisiana	LaFourche	Golden Meadow	Miocene	Screen	New well	1000	0	750
Louisiana	LaFourche	Golden Meadow	Miocene	Perforated	New well	1000	0	477
Louisiana	LaFourche	Golden Meadow	Miocene	Screen	Old well	1000	Show	30
Louisiana	LaFourche	Golden Meadow	Miocene	Screen	Retreatment	1000	27	300
Louisiana	LaFourche	Golden Meadow	Miocene	Screen	Old well	1000	100	250
Louisiana	Baton Rouge	University	Miocene	Perforated	New well	1000	0	140
Illinois	Hamilton	Hoodville	Cypress	Open hole	New well	500	75	130
Wyoming	Niobrara	Lance Creek	Leo	Perforated	New well	1000	14	1500
Texas	Jefferson	West Beaumont	Miocene	Perforated	Old well	1000	Dead	360
Texas	Jefferson	West Beaumont	Frio	Screen	Retreatment	1000	10	45
Texas	Jefferson	West Beaumont	Miocene	Perforated	Retreatment	1000	20	80
Texas	Orange	Orange	Frio	Perforated	Old well	1000	0	80
Texas	Orange	Orange	Frio	Screen	New well	1250	0	60
Texas	Orange	Orange	Frio	Screen	Retreatment	1250	Dead	80
Texas	Orange	Orange	Frio	Screen	Old well	1000	0	178

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Design of Cracking Units

Synopsis of Preceding Meetings

The first discussion involved a review of the various hydrocarbons and their thermodynamic qualities as related to the cracking of petroleum and its products. The main hydrocarbons in petroleum and its cracked products are paraffins, olefins, naphthenes, and aromatics. Of these, olefins are virtually non-existent in most crude oils.

Chemical stability. The more unsaturated a compound is the more chemically reactive it is.

Relative crackability of hydrocarbons. The longer a molecule is the easier it is to crack and the more compact it is the harder it is to crack. The long straight-chained paraffin hydrocarbons and compounds with such hydrocarbon side chains are the first to be affected by cracking, and constitute the most important reaction involved in cracking.

Energies released or absorbed in cracking. Inasmuch as Newton's first law (which states that energy can neither be created nor destroyed) applies, the products of reaction contain as much heat of combustion as the original compound, plus or minus the heat of reaction, which is always a term in the thermodynamic equation.

Decomposition reactions. The decomposition reactions of cracking involve either (1) the formation of two smaller compounds or (2) dehydrogenation (the splitting-off of free hydrogen). Of the two, the former takes place at a much lower temperature. The smaller and more compact the hydrocarbon the higher the temperature necessary.

Effect of pressure on reactions. So far as the original or primary reactions are concerned, the pressure effect is very slight. High pressures are used principally to limit the size of the equipment and thus make the process more economical.

Development of cracking. The ability of petroleum to crack was discovered by the accidental overheating of a topping shell still, resulting in an unexpected straw-colored distillate, which was in reality cracked distillate. The experiments that followed led to the first patents on cracking, which were granted to Young and Benton in 1865.

The first commercial unit was developed and put in operation by Dr. Burton of the Standard Oil Company of Indiana in 1912. The equipment consisted of a shell still with removable bottom plates to facilitate coke removal. It differed from earlier models in that it had an aërial condenser, which served to recycle the heavy ends. This still operated at temperatures as high as 750° F. at about 35 lb. per sq. in. pressure, and had a 48-hr. cycle of operation. It had the following operating difficulties that all later models endeavored to eliminate.

1. Excessive coke deposition
2. Short cycle
3. Low gasoline yield
4. High operating cost
5. Unsafe
6. A low-grade product
7. High cost and short life of equipment

The Burton-Clark unit, developed in 1915, used a water-tube boiler to get better circulation of oil to reduce coke formation and a bubble tower for better separation of product and recycling. It operated on a 72-hr. cycle.

The Coast still, appearing first in 1916, used lower temperatures and large volumes of oil in order to reduce coke and gas formation. It retained the shell still principle, but had a chain scraper that worked continuously to remove the coke from the bottom to a bin at one end, thus providing a longer operating cycle.

The Fleming still was a vertical cylinder heated on the sides in order to get good oil circulation and to reduce coke formation and deposition. Trouble was experienced, however, because of local overheating that caused the still sides to bulge.

The Dubbs process, the basic principles of which were patented in 1915, used high pressures, had an outside reaction chamber for coke collection and separation of the flashed liquid. It also employed a coiled chain or cable, used to break up the coke and facilitate its removal. The later widespread acceptance of Dubbs units did not gain impetus, however, until the development of the pipe still. The Dubbs units eliminated most of the shortcomings of the earlier units.

The Isom (1915) and the Cross (1922) were similar in that they operated at high pressures of 600 to 700 lb. per sq. in. and had outside soaking drums, the function of which was to continue the reaction begun in the still. These units produced a synthetic crude oil, which was then separated by distillation.

Clean recycle. The importance of clean recycle was first recognized when operators of earlier units discovered that clean stocks permitted longer runs with correspondingly smaller percentages of gas and coke formed.

The Jenkins unit was described as being somewhat similar to the Burton-Clark except that forced circulation was employed through the tubes. The increased velocity gave quicker heating as well as less coke formation. The Jenkins was the first unit to add the charge to a dephlegmator, which was recycled with the rest of the bottoms back to the coils.

The Holmes-Manley units developed by The Texas Company in about 1920 used multiple towers in order to obtain continuous operation, thus cutting down operating costs, but the additional towers added to the investment costs.

The Winkler-Koch still had as its principal objective the reduction in investment costs. In this unit the reaction chamber was eliminated entirely and by more exacting time and temperature control all the cracking was accomplished in the tube still heater, quenching immediately afterward to stop the cracking reaction. This unit marked the beginning of the modern methods of time and temperature control, together with the use of clean oil charging stocks.

An attempt to get away from coke formation in the tubes, together with the manufacture of a superior product, was the purpose of the Gyro vapor-phase cracking unit. Although coke was formed, it was fluffy and easily removed by the sweeping action of the gases in the tubes. High investment costs and large gas formation were the chief disadvantages of this unit. Cracking in the vapor phase involves handling large volumes of gases at relatively low pressures. The addition of the DeFlorez furnace to the vapor phase process improved the situation because of the efficiency of the circular tube arrangement. The DeFlorez units operated at a temperature of approximately 1080° F. and a pressure of 100 lb. per sq. in. pressure.

Class Meeting No. 4

Leader: In last week's meeting we discussed the type of cracking equipment that would yield maximum gasoline. We had progressed to considering two coils and I believe we should continue that discussion tonight.

We would take the clean oil that is between the boiling range of the gasoline and the boiling range of the charge and return that through another coil in the furnace and join the dark oil coil before entering the reaction chamber. Does anyone have any objections to that method?

Pupil: I have a question. The reaction chamber was set up principally as a time element. You have a dark oil and a clean oil—with different temperatures in the furnace, and yet you use the same chamber—is that best?

Leader: I think that is a very good point. Let us assume the outlet of the heavy oil coil is 800°F. (427°C.) and the outlet of the clean oil coil is 1000°F. (538°C.), and you are joining these two hot oils before carrying them over into the reaction chamber. The question is how can you control their reaction when you have 1000° on the clean coil and 800° on the other, and in the chamber you have a certain time element. How do you adjust the operation of the furnace and the reaction chamber to give the best yields?

Pupil: Quenching is one method.

Leader: The clean oil coil will carry much more oil than the dark oil coil

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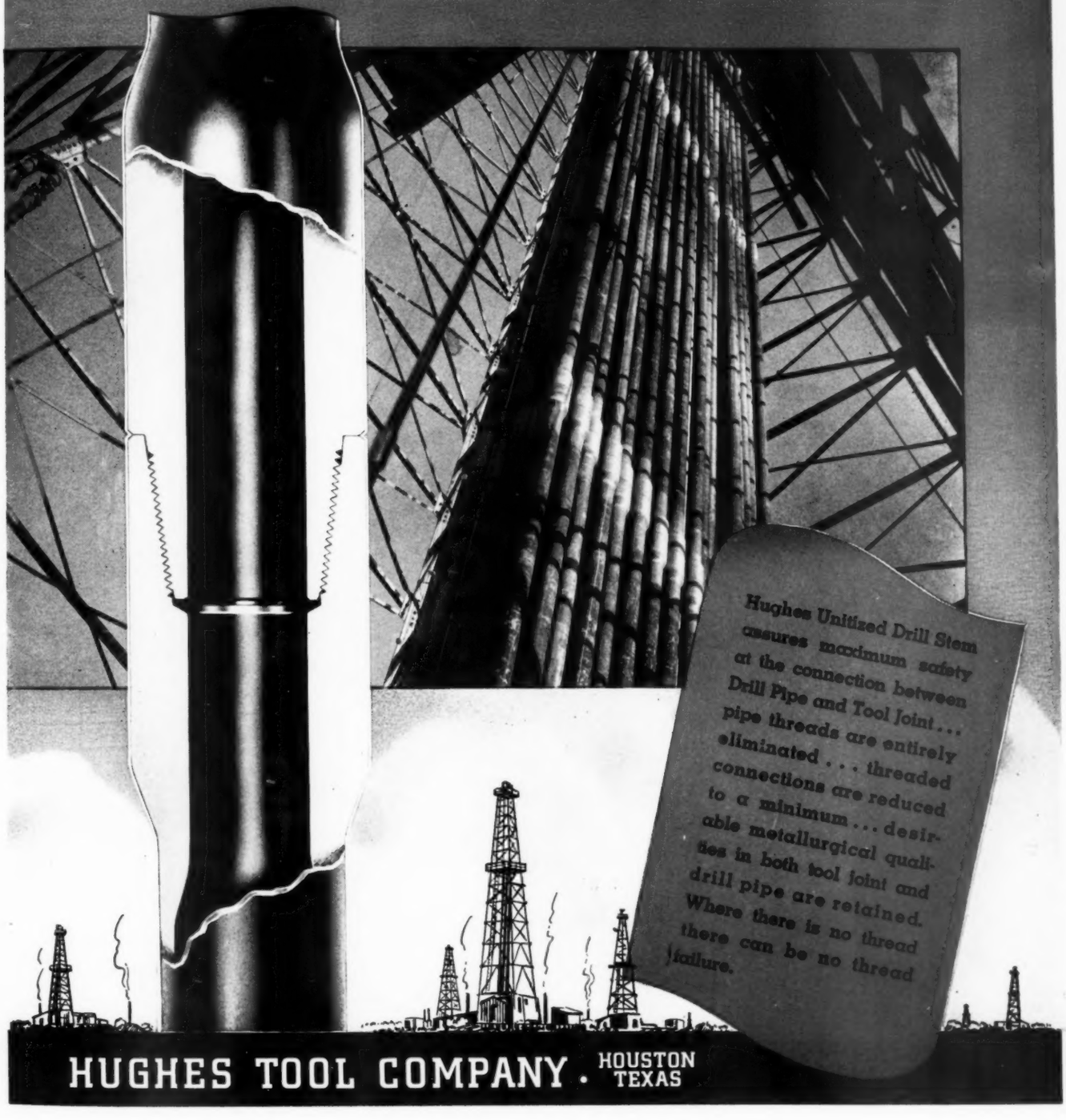

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probably, and for that reason you are going to have a predominance of hot oil that contains more heat than you really want to subject the dark oil to, and you might get a higher gas loss than desirable. Likewise a coke of questionable quality might be obtained.

Pupil: Could we add just enough of the clean hot oil to the dark oil to give a correct final temperature, and dispose of the remaining clean oil in another manner?

Leader: I believe there is a more practical way out of this difficulty. If we don't take anything off the fractionator except gasoline, we have a tremendous amount of clean oil in the tower bottom and the chances are that this process as it is set up here isn't very practicable for that reason. What we have to do is attempt to get both coils in balance with respect to heat content and oil content. If we could divide our oils so that about half goes to the dark oil coil and half to the clean, then we could get the results we are after. Is that the way you would analyze it?

Pupil: Yes.

2nd Pupil: That would somewhat nullify the benefits, would it not?

3rd Pupil: Why 2 coils? Why not 10 coils?

Leader: That is a good point which we will discuss in some future meeting of the class.

Leader: Let us set up some more or less arbitrary figures. Let us use a figure of 835°F. (446°C.) for the temperature of the vapors coming into the dephlegmator. If we take only gas and gasoline out at the top (operating at 200 lb.) the top temperature would be about 525°F. (274°C.) If we are operating here for maximum gasoline, all the material that is refluxed will be circulated through the heater and again exposed to cracking conditions.

For each bbl. of oil entering as charge, how many bbl. are you getting back from heater and reaction chamber?

Pupil: Someone said last week about 6 to 1 recycle ratio.

Leader: You would have probably at least 5 times as much returning.

Pupil: The present coke units have a ratio of slightly less than 3 to 1, but we thought we could do better than that.

Leader: But you are taking out some recycle, are you not?

Pupil: Yes, about 2¾ to 1.

Leader: Let us say that we have 4 bbl. coming back for each bbl. going in. That is not unreasonable. What will happen if you have 835° F. material and 4 times as much as you have raw feed. How are you going to supply the cooling to bring that down to 525°F.?

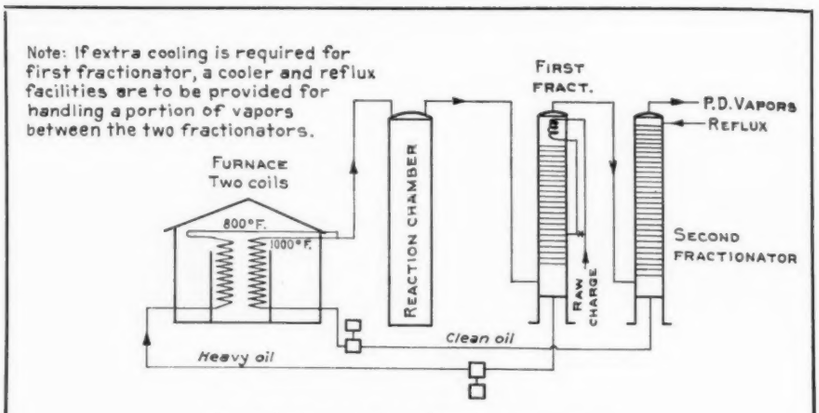


Fig. 10. Two-coil cracking arrangement

Pupil: You have to have a cooling coil in the fractionating tower.

Leader: What are you going to use in this coil?

Pupil: The charge.

Leader: Yes. One way is to use the closed coil near the top and spill the oil at a level well down in the column. Even that is not going to give you the cooling to make end-point gasoline. I believe that you will find the best way is to build a second fractionator as in Fig. 10 and cool that tower by reflux. The advantages of this method are that you can take over as much material into the second fractionator as you want to recycle through the clean oil coil. If you want to increase the amount of oil going through the clean oil coil, you increase the top temperature of the first fractionator and permit more material to come over. If you want to increase the amount of oil in the dark oil coil, you lower the top temperature and that throws more material down the column. How is that done in practice?

Pupil: By water, after using all the cooling effect of the raw charge.

2nd Pupil: Well, that's reflux, isn't it? Water to condense and cool the reflux material.

Leader: Yes. The use of this method is for the purpose of balancing between clean and dirty oil.

Now, what are we going to do with the problem in the cracking operation, whereby the amount of heat added to the oil to crack it is greater than you can recover with the charge? It seems you have two choices — to cool the vapors with water or with oil from some adjacent equipment. I would suggest that vapors go first to a stabilizer and there heat the reboiler on the stabilizer equipment.

Pupil: Or combustion unit?

Leader: Yes, when you need to heat crude oil to high temperatures. Well, the only argument that we can have on this process is whether we would use one fractionating column or two fractionating columns. In my way of looking at it, the two columns give you a much more positive control of the oil returning to the furnace. It is very necessary to control the quantity of oil coming back through the clean oil coil and the dirty oil coil in order to establish transfer temperatures that would result in a proper time in the reaction chamber. In the formation of coke, a very slight change in temperature will make a coke either too hard or tarry.

Pupil: Why couldn't you do that with just one tower?

Leader: You could. It would require an internal exchanger in the tower. If you put those towers one on top of the other, you would have the same thing as one tower.

Pupil: You would have a side stream for the clean oil circulation.

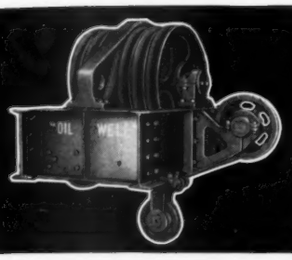
Leader: The material removed in the side stream contains more overlapped fractions, whereas the material off the first fractionator is a stripped product and thus gives clean bottoms in the second fractionator. You can't put a steam stripper on the single fractionator job.

The whole point is you are getting a very complicated piece of equipment in this tower; you will find that it is cheaper to build the second tower and thus have a piece of equipment that can be operated independently. If you have the internal exchanger, then you have a much more difficult maintenance problem than when you have the equipment on the outside.

Pupil: Why is it that 800°F. oil doesn't quench 1000°F. oil from the other coil before it ever has time to complete the reaction?

Leader: You can design the cracking coil so that the reaction on the clean oil is complete at this point.

Pupil: Why not run it to the fractionating tower at once? In a light



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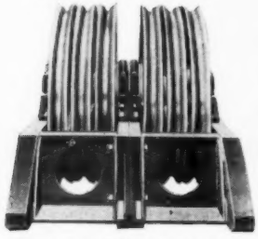

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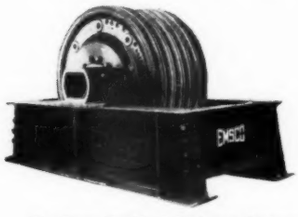

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material you wouldn't get coke anyway.

Leader: What are you going to do with the 1000°F. material?

Pupil: There is one reason for heating it that high—to heat black oil to crack it more completely.

Leader: Aren't you quenching it with the cooler oil?

Pupil: With 800°F. oil?

Leader: Yes. You complete the reaction by going to a high temperature and then quenching.

Pupil: That dirty oil doesn't receive too much cracking?

Leader: No. The time and temperature are properly controlled.

2nd Pupil: It is the total time in the heater, in transfer lines, and in the reaction chamber that does the job.

Leader: Regardless of the fact that they talk about clean oil coils and little coke formation, there is still some residue that has to be removed so it is well for it to go to the coking chamber, and not directly to the fractionating tower.

Pupil: There is a distinct advantage in cracking the light material in the furnace and a distinct disadvantage in completely cracking the dirty oil in the furnace.

Leader: The dirty oil is in the cracking range, but the temperature and the time are adjusted; so you will get coke, it is true.

Pupil: That makes a complicated situation when you have to change your temperatures to control coke quality.

Leader: That's the way they operate the Dubbs units.

Pupil: They don't have 2 coils.

Leader: What would be more difficult about changing the temperature in this furnace than in the single coil? You should not change the temperature at the outlet of the clean oil—if you vary that temperature you will either over-crack or under-crack. The point is you need to increase to transfer temperature gradually as the reaction chamber fills. That can be accomplished by increasing the temperature of the heavy oil furnace section, the temperature on both sections, or cutting down the charge.

Pupil: You have about four different choices already.

Leader: You don't have to use all four of them, you can use the one that turns out to be best by experience or practice.

Pupil: Oh, it will work.

Leader: Well, I'm glad to hear that.

The final portion of the lesson had to do with the calculation of yields on this particular operation. We had a couple of study groups who spent all their time on the theoretical side of it. Perhaps you can enlighten us on this point. What methods would you use for determining the yields of gasoline, gas, and coke?

Pupil: We didn't study that at all. Our group leader gave us a two-hour discussion on coke.

Leader: Did any of the other groups delve into this matter?

Pupil: We didn't get anywhere in our group.

Leader: How about one of the other groups?

Pupil: We didn't either.

2nd Pupil: We used Nelson in studying that point.

Leader: Will you give the page number in Nelson's text that covers that?

Pupil: I think I can. It is p. 316, (*Petroleum Refinery Engineering* by Nelson). From Sachanen, we obtained the following formula (equation 39, p. 162, Sachanen). For fuel oils:

$$Y = 303 - 250S$$

in which Y equals the yield of gasoline and S equals the specific gravity of the charging stock.

We worked it out by that formula and were very optimistic and guaranteed 78½ percent yield. To be conservative, we used 75 percent.

Leader: In your problem, what value of S did you use?

Pupil: The value of S was 0.898 in this case. We have a coke yield of 22 percent and gas 18 percent.

2nd Pupil: Is that coke yield about 65 lb. per bbl. of oil charge?

Leader: Approximately.

Does anybody want to discuss these figures? Is the gasoline yield too high?

3rd Pupil: The gasoline and coke yields appear to be a little high, I would say, on the basis of actual data upon various runs reported by Universal Oil Products Company engineers and some of our experiences with it.

Leader: Perhaps you have that information. If you do, it would help certain class members, but I have not yet seen a unit that made gasoline as the only liquid product.

Pupil: A U.O.P. run made exclusively for gasoline and from a comparable charge shows 71 percent gasoline and 20 percent coke.

Leader: The 75 percent gasoline may be a little high, though substantially in line with expectations.

Leader: I believe it was agreed last week that we would attempt to develop a process for obtaining maximum gasoline yield from a 26° A.P.I. Kansas residuum charge. I will assume that everybody is well fortified with arguments and evidence. My rôle in this part of the meeting will be that of a discussion leader rather than a teacher, I hope. I wonder if one member of each group would step to the blackboard and put on their group's flow sheet, and while they are doing that, we will carry on the discussion. In working out a plan for making a maximum gasoline yield, what is the plan of attack that group A used?

Pupil: We established a possible yield of 78½ percent gasoline and then began our problem on the heating curve using that figure as a basis.

Leader: Before you could work out a heating curve, weren't there some other matters that had to be decided?

Pupil: Yes, we had to determine a furnace outlet temperature and figure on the pressure and time of cracking.

Leader: Let's begin with the first of those. How would you determine the outlet temperature?

Pupil: We discussed the time of reaction. We then decided the length of the soaking coil had to be short enough to be practical and after we decided on what we thought was a practical soaking coil, then we were in a position to determine the temperature.

Leader: In other words, in order to determine temperature you had to determine time?

Pupil: Yes.

Leader: Let's have another group. We would like to have one of the men in group B tell us how to go about determining the time and temperature required for cracking.

Pupil: We took the following formula from the text*:

$$k = \frac{1}{t} \log_{nat} \frac{A}{A - x} \quad . \quad . \quad . \quad (8)$$

in which:

k = reaction velocity constant
t = reaction time
A = initial concentration of product
x = volume of product cracked in time t.
$A - x$ = amount of residuum or recycle stock.

We figured from that formula to get the cracking time required. We planned on cracking between 12 and 15 percent per pass, and then calculated a cracking time of 5.7 sec. at 1000°F. for the recycle stock soaking time in the furnace. This is confirmed on page 112 of Sachanen, in which it states that at 1022°F. for 30 percent cracking it requires 8 seconds. At the bottom of p. 108 a statement is made that the rate of gasoline formation for best recycle stocks in the mixed-phase process may be assumed to be approximately 2½ times smaller than that for straight-run gas oils. So we assumed this recycle stock would be 2 or 2½ times as hard to crack as straight-run gas oil.

*Equation 32a, p. 105, *Conversion of Petroleum*, by Sachanen.

EDITOR'S NOTE: Proceedings of additional class meetings will appear in subsequent issues of *The Petroleum Engineer*.

2. New Mission Compound 308 valve inserts give longer life under all conditions and cut insert costs more than half.
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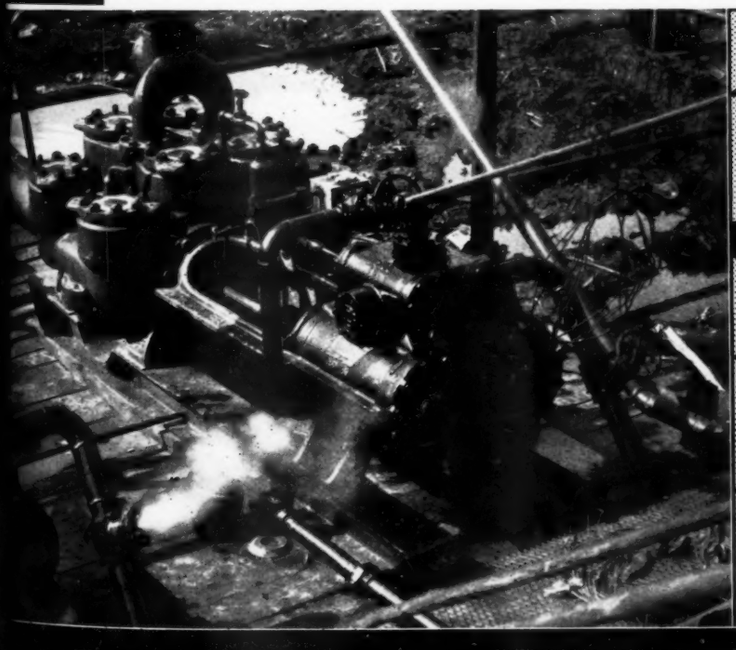
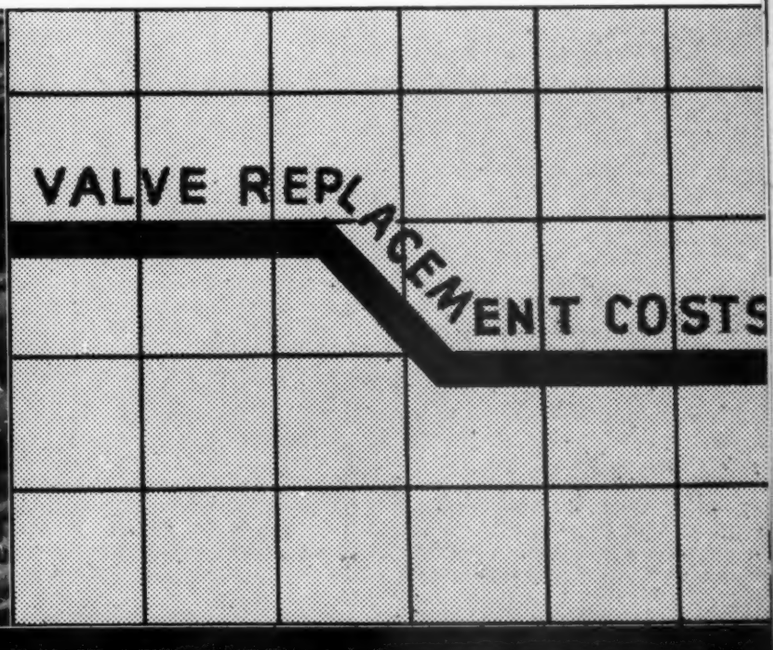




S ARE IN USE THAN ANY OTHER MAKE

Drilling Shallow Wells Profitably In The North Texas Area

Exclusive

☆ Kelly is laid down because surface rock makes rat-hole digging expensive — one-engine portable rig is moved as a unit

by H. Lee Flood
Associate Editor

WHAT makes the difference between a success and a failure in contracting to drill an oil well? Some say it is in knowing the detailed costs of each element of the drilling operation down to the penny. Certainly every contractor recognizes the value of an accounting system of some kind and there have been repeated requests for more details as to how an accounting system could be set up for drilling operations that would really *work;* but the best accounting system in the world can be but a poor substitute for an active, intelligent solution of the problems that arise from day to day in the drilling business plus that valuable though seldom found ability to look ahead and sense the broader pattern of things to come.

Many contractors have sensed and recognized the significance of the sensational developments of lighter, portable rotary drilling equipment that have occurred during the last five years. Many have also watched the development of the heavier and yet heavier drilling equipment that has been needed to exploit the oil reservoirs of the Gulf Coast and of California. Although these deeper activities play an important role in the broad progress of the petroleum industry, attention is here called to the increasingly important place that shallow drilling of smaller pools is assuming in the present and future of the industry.

As in so many disconnected developments occuring within as vast an industry as petroleum, it is difficult for the average man to assess the importance of random, shallow drilling of small 10- to 50-well pools. Yet it is to this type of development that more and more operators, large and small, are turning and it is this type of drilling that will perhaps be of greatest importance in bolstering the nation's supply of petroleum for many years to come.

Assuming that success attends the search for oil at shallow depths under the present-day widespread application of relatively low well allowables, what constitutes the ability to drill, complete, and produce such a well profitably?

The obvious answer is to reduce all costs to the lowest figure possible and this answer centers attention principally on a reduction in well investment. In broad terms, the principal items constituting well investment are "drilling cost" and "cost of casing." A desire to reduce the latter item has been the incentive behind the trend to slim-hole drilling. To reduce drilling costs has been the purpose of all the relatively lightweight portable drilling equipment that has appeared on the market.

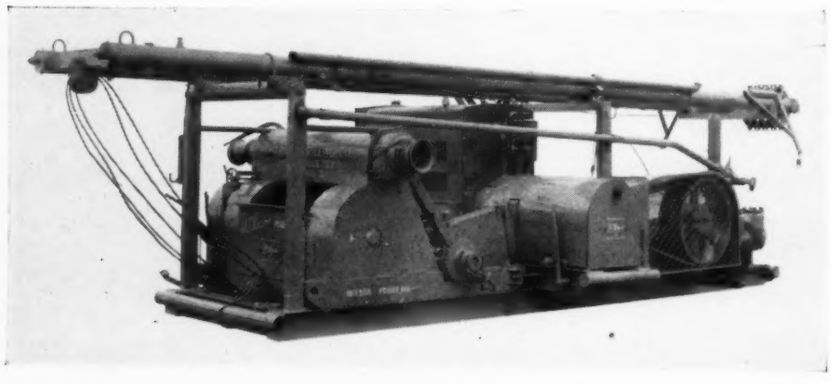
The widespread use of the term "slim-hole drilling" has occasioned confusion among many in the industry, particularly on the question of whether it represented its literal meaning —that of being a smaller hole, or described the type of drilling equipment with which such a hole could be drilled.

One of the best examples of the manner in which relatively "small" drilling contractors are digging in and keeping abreast of the times, thereby enabling them to operate at a fair profit, is to be found in the Voth field, immediately south of the town of Muenster in Cooke County, Texas, approximately 15 miles west of the city of Gainesville.

Initially the Voth field was developed on the basis of production found at depths of 1620-1735 ft. Later the field was found to be productive at depths of 1100-1300 ft. The deeper production is from the Ellenburger formation; the shallower and more recent development is in the Strawn sand.

Recognizing the need for drilling equipment of the fastest, lightest, most economical type in order to develop the shallow Strawn sand, the contractor in question specified a drilling rig that would represent a reasonable investment and be readily portable with a minimum delay in tearing-down and rigging-up.

The drilling rig specified by the contractors and built for their use is shown in the accompanying photographs. The unique feature of the entire assembly is the single 165-hp. engine used to supply power for the entire operation. It is also interesting to note that only one mud pump is available in drilling with this rig. The entire assembly, including a 65-ft. telescoping mast is mounted on a single skid that permits the rig to be moved as a unit on a heavy-duty truck. The units are fixed in place and thus are



One-engine portable rig in readiness for moving

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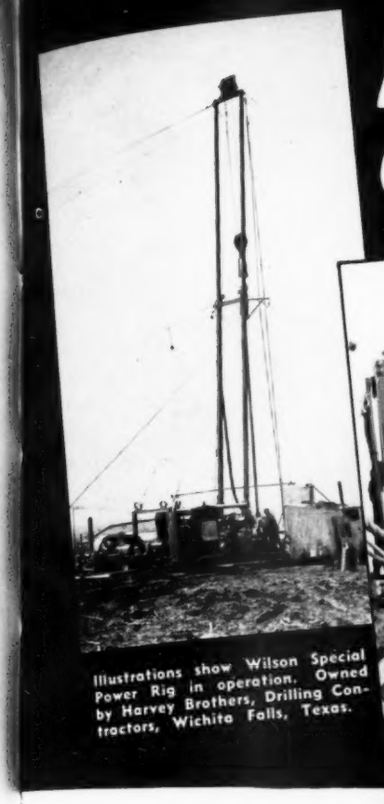
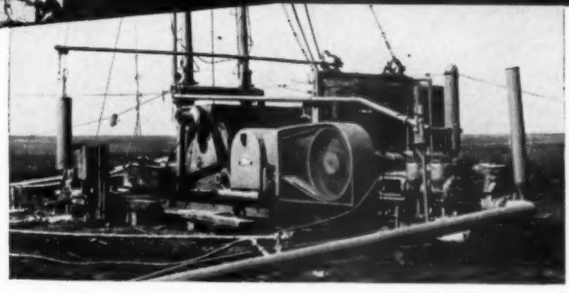
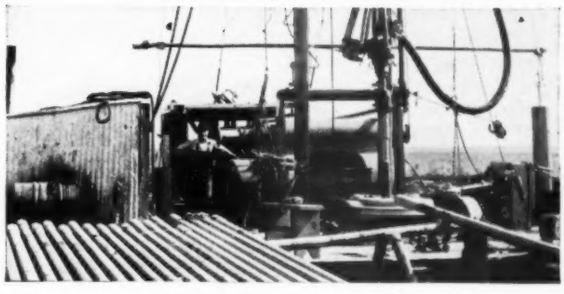


Illustrations show Wilson Special Power Rig in operation. Owned by Harvey Brothers, Drilling Contractors, Wichita Falls, Texas.





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always in perfect alignment and no time is lost in lining-up after a move is made. Total weight of the rig is 47,000 lb. When highway requirements prohibit this weight or special permits cannot be obtained, or when the going is soft underfoot, the engine and pump can be moved separately on their respective skids.

The one-engine rig is the first of its kind assembled in the Mid-Continent, so far as is known. The principal objective in its design was to create a drilling machine that would achieve the maximum in portability. Cost analyses involving heavier drilling equipment have indicated that the cost of tearing down, moving, and rigging-up constituted a major item of expense.

By employing one large engine as a prime mover instead of two smaller engines, full use of the installed horsepower can be obtained at all times.

Nearly all light drilling rigs heretofore have been designed to operate either with separate engines (one on the drawworks and one on the pump) or with two small engines compounded. In the first arrangement (two separate engines) one engine must be large enough to operate the drawworks, when hoisting the pipe and to drive the table otherwise. The second engine is used to drive the pump. When two small engines are compounded, they are usually of the high speed type.

When a single engine of the larger type is used as in the rig being described, surplus energy available during normal drilling may be utilized in the pump where it is most useful. When it is necessary to make a trip all of the available horsepower may be diverted to hoisting except for the small amount needed to maintain circulation.

The rig described is equipped with chain transmission, suspended at three points so that all shocks emanating from the table or drawworks are prevented from reaching the engine crankshaft. Important, too, is the arrangement whereby a shutdown caused by chain breakage is obviated. For example, if the driller is running the rig in second and the second chain should break, the transmission can be shifted into low and normal operation may be continued.

In operating the hoist, the driller has the choice of either a friction or a jaw clutch to facilitate control. The friction clutch is designed for sufficient capacity to accommodate all normal loads encountered in shallow well drilling and the jaw clutch provides the additional capacity required for extra heavy loads.

Indicative of the precision and durability being built into the leading rigs of this lighter type are the high-capacity roller bearings with which all shafts are equipped. All shafts are made of SAE 4145 chrome moly heat-treated steel, accurately ground to size and splined for all clutches to eliminate loose keys. Jaw clutches are made of SAE 3115 low carbon nickel steel castings, case-hardened after machining.

The rig is equipped with a 4-in. oil-bath swivel and a 17-in. rotary table of the small type.

Not often seen on modern rigs, a fluted kelly is used, principally because of the ease with which it may be rolled and otherwise handled.

All drill pipe is laid down on a rack instead of being stood in the mast. To assist in racking the pipe when coming out of the hole, a hook on a trolley is used to engage the lower end of each stand and carry it out so that the pipe may be rolled onto the rack. This provision eliminates the need for a fourth (derrick) man, thus enabling a 3-man crew to operate the rig handily.

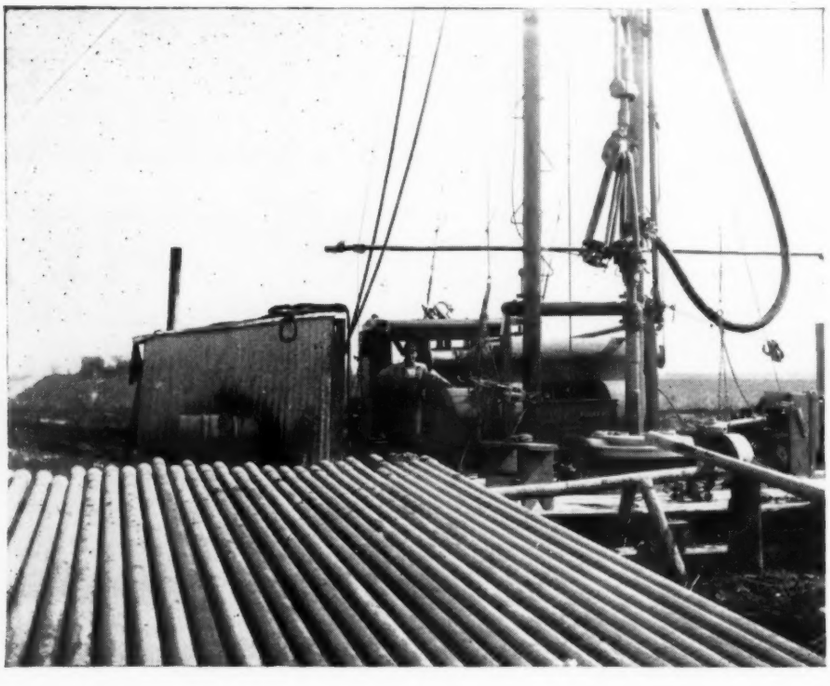
As an example of ingenuity, the owners of this rig, adjusting their methods to the local field conditions, have eliminated the drilling of a rat-hole to receive the kelly and are laying the kelly down while a trip is made. This innovation is justifiable in this instance because the top 50 or 60 ft. of drilling in the field is hard rock digging. Offset operators, adhering to the practice of drilling a rat-hole, consume 18 to 24 hr. for the operation, the time required to drill 25 to 30 percent of the rotary hole.

The one-engine rig has been in service only two months and in that time has drilled eight wells as follows:

Well No.	*Depth, ft.*	*Time, on and off (including move)*	*Size hole, in.*	*Size casing, in. O.D.*
1	1307	11 tours	9	7
2	1275	9 tours	9	7
3	1260	11 tours	9	7
4	1285	11 tours	9	7
5	1295	11½ tours	9	7
6	1286	10½ tours	9	7
7	1298	10 tours	9	7
8	1301	11 tours	9	7

In drilling with this rig to these shallow depths, 4½-in. drill pipe is being used. The contractor owns a heavier rig drilling deeper and more important wells elsewhere and the drill pipe from the heavy rig is passed on to the light rig as "hand-me-downs." This combination permits full utilization of the drill pipe without incurring hazardous risk of twistoffs.

The single mud pump used on the rig is of the modern outside-crank type with heavy-duty tapered roller bearings on the crankshaft and crank pins. The maximum liner size is 6-in. and the stroke is 12 in. The fluid chamber is recommended for a maximum discharge working pressure of 1800 lb. per sq. in., tested to 3000 lb. per sq. in. hydrostatic pressure. At maximum operating speed of 65 r.p.m. when equipped with full-size liners, theoretical displacement of the pump is 364 gal. per min. and recommended maximum brake horsepower input is 129. The one-piece semi-steel fluid end of the pump is of the direct-flow type with no internal walls subject to internal pressures.



Drill pipe and kelly are laid down to eliminate expense of derrick man and of digging rat-hole

Computation of Charts on High-Pressure Gas Meters*

PETROLEUM ENGINEER EXCLUSIVE Feature

☆ Introduction of factor to correct for liquid seal is suggested in addition to supercompressibility coefficient

by R. O. Cox

Chief Clerk, Gas Measurement Department, Lone Star Gas Company

A METHOD of calculating the compressibility of gaseous mixtures at different temperatures and pressures when only the gas analyses are available was advanced by Brown and Holcomb in 1940.[1] Inasmuch as analyses of gas handled and operating temperatures and pressures form the basis of practically all other gasoline plant calculations, this method offered a ready means of calculating compressibility factors from data already available, and aroused widespread interest among operators of high-pressure plants.

The principal difficulty in using this method on gas from high-pressure wells that contain large quantities of natural gasoline is in obtaining a true sample of the gas due to condensates collecting in the sampling drum. Many plant operators are now correlating an analysis of the residue gas with products removed in the plant to determine the composition of the inlet or raw gas. The analysis of the raw gas thus obtained is used to compute both specific gravity and compressibility.

Application of the abovementioned method for determination of supercompressibility factors on high-pressure well meters in Grapeland field, Texas, were described in a recent article.[2] Basic orifice coefficients for the thick-walled pipe used in meter runs on high-pressure gas were discussed in another recent article.[3] The purpose of the present article is to supplement the articles mentioned with additional remarks and data to present all factors and calculations involved in computing meter charts measuring both raw and residue gas at a high-pressure gasoline plant involving the return of residue gas to the producing sands. Some repetition will therefore be necessary.

R. O. COX

graduated in textile engineering from Texas A. and M. College in 1925—Spent one year in a textile plant at McKinney, Texas, and then joined the gas measurement staff of the Lone Star Gas Company as meter inspector at Ranger, Texas—Later transferred to main office in Dallas, Texas, and was promoted to present position in 1929—Has been active in the educational program of his company, having taught classes in natural gas studies—Has been active in the annual Gas Measurement Short Course of the University of Oklahoma and presented papers before meetings of that body.

An important factor involved when orifice meter piping is equipped with seal pots is the "liquid seal factor." Seal pots are necessary when measuring extremely wet gas from wells producing condensate that collects in the mercury chambers. The seals serve to maintain the same liquid level above the mercury in both chambers. Various operators have tried different kinds of liquid in the seal pots, but in most cases the pots are allowed to fill with condensate from the gas being measured. Most gas sands, however, contain some quantity of water—either fresh water trapped in the sand or salt water. This water finds its way into the seal pots and meter piping, and being heavier than the condensate, eventually displaces the liquid in the seal pots. Although some gas may be mixed with the water and thus reduces its specific gravity, there is no way of telling what degree of mixing occurs under actual operating pressure. In computing the seal factor, however, it seems reasonable to assume that the sealing liquid has approximately the same specific gravity as pure water, or slightly less. On a meter equipped with seal pots, each 13.6 in. water differential (the equivalent of 1 in. of mercury) represents 12.6 in. actual differential plus 1 in. of sealing liquid. A correcting factor must be applied, therefore, to compensate for this error in recorded differential.

The correcting factor to be applied to the coefficient when seal pots are filled with water would be:

$$\sqrt{\frac{13.6-1}{13.6}}=\sqrt{\frac{12.6}{13.6}}=0.9625$$

If the sealing fluid under operating conditions were eight-tenths as heavy as water, the liquid seal factor would be:

$$\sqrt{\frac{13.6-(1\times 0.8)}{13.6}}=\sqrt{\frac{12.8}{13.6}}=0.9701$$

The water or other fluid floating on the mercury would have some buoyant force that would tend to prevent the float from settling to the proper point in the mercury, but this can be corrected by adjusting the differential pen to the correct zero position and no correction is then necessary in figuring

(Continued on Page 82D)

*The data in this article will be included in a paper "Making Gas Measurements Balance in a Cycling Plant," to be presented by Don A. Sillers, Lone Star Gas Company, before the Natural Gasoline Association of America, April 23-25, Dallas, Texas.

[1]See "Compressibility of Gases," by George Granger Brown and Dysart E. Holcomb, *The Petroleum Engineer*, January to April, 1940 (inclusive).

[2]"Calculating Supercompressibility Factors," by Roy L. Cochran, *The Petroleum Engineer*, March, 1941.

[3]"Orifice Coefficients for Thick-Walled High-Pressure Piping," by D. A. Sillers, *The Petroleum Engineer*, February, 1941.

FIRST GAS L

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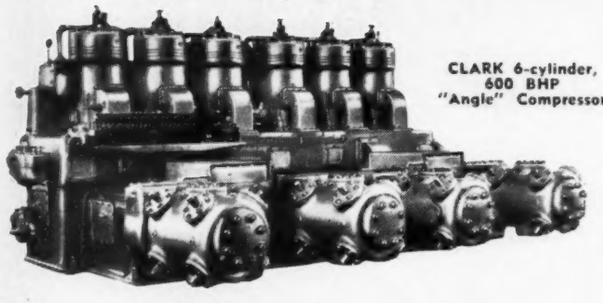

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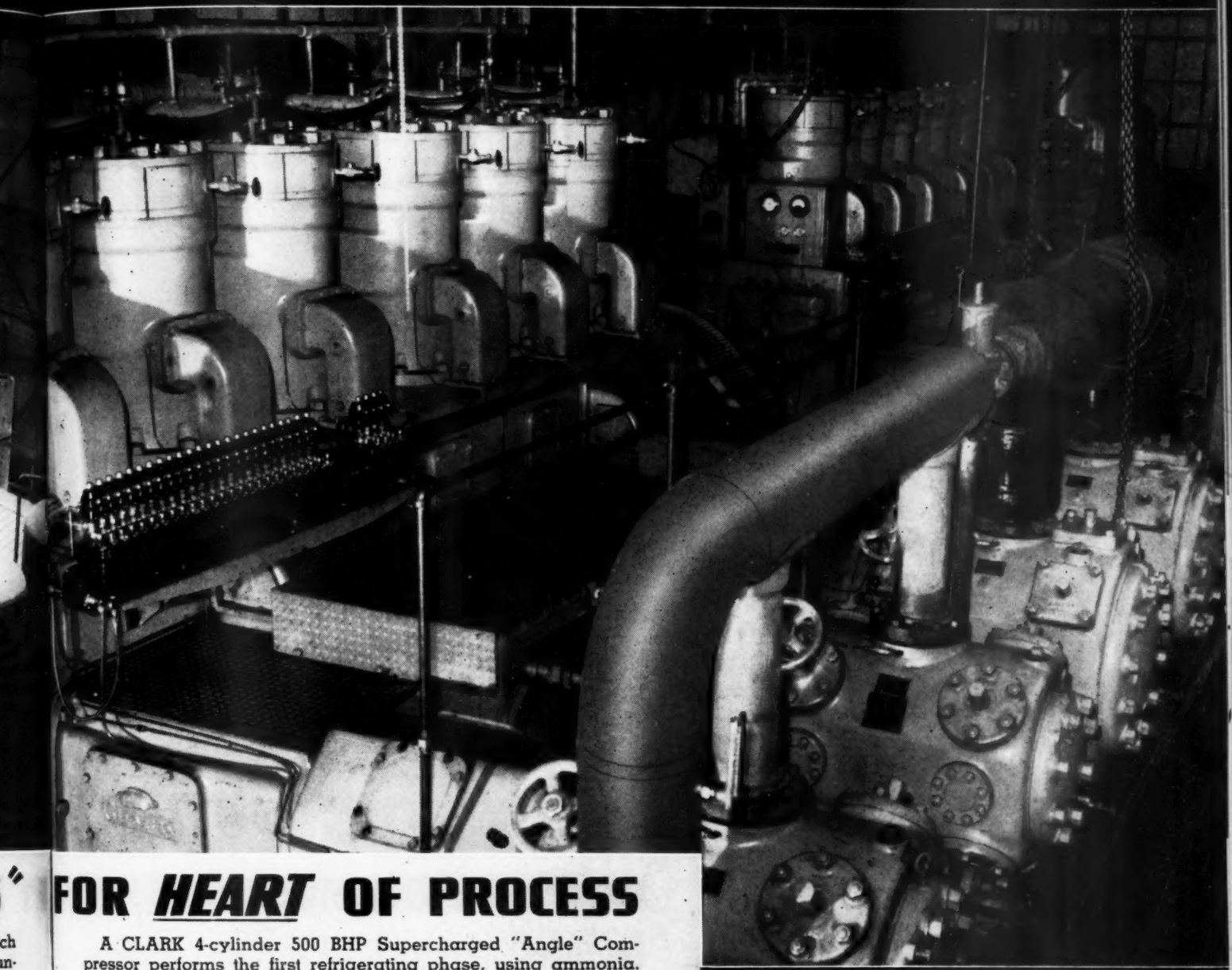

One 4-cylinder and Two 6-cylinder CLARK "Angles", in Refrigeration Service, East Ohio Gas Co., Liquefaction Plant

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A CLARK 4-cylinder 500 BHP Supercharged "Angle" Compressor performs the first refrigerating phase, using ammonia. Two CLARK 600 BHP "Angles", totalling 1,200 BHP, then perform the second refrigerating phase, using ethylene. All three of these CLARK units are fitted for 2-stage compression and are specially equipped, and all have automatic recording instrument type speed control.

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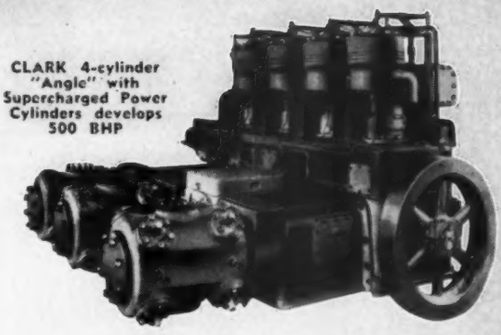

CLARK 4-cylinder "Angle" with Supercharged Power Cylinders develops 500 BHP

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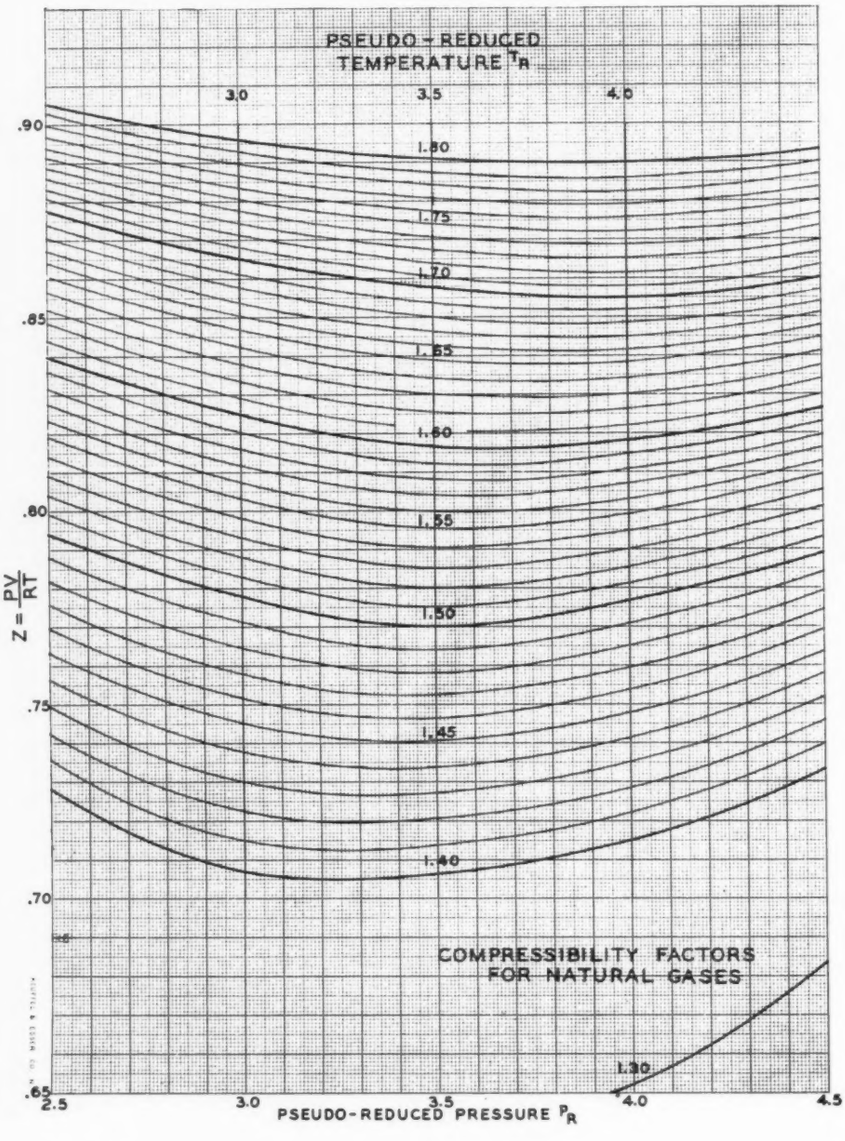
TABLE 1

(1) Raw gas		(2) Fraction	(3) Molecular weight	(4) (2)×(3) product
Methane	CH_4	0.8185	16.04	13.13
Ethane	C_2H_6	0.0829	30.07	2.49
Propane	C_3H_8	0.0432	44.09	1.90
Isobutane	C_4H_{10}	0.0069	58.12	0.40
nButane	C_4H_{10}	0.0157	58.12	0.91
Pentane	C_5H_{12}	0.0112	72.15	0.81
Hexane	C_6H_{14}	0.0216	86.17	1.86
		1.0000		21.50÷28.9=0.744 sp. gr.
Residue gas				
Methane	CH_4	0.8662	16.04	13.89
Ethane	C_2H_6	0.0802	30.07	2.41
Propane	C_3H_8	0.0354	44.09	1.56
Isobutane	C_4H_{10}	0.0042	58.12	0.24
nButane	C_4H_{10}	0.0102	58.12	0.59
Pentane	C_5H_{12}	0.0036	72.15	0.26
Hexane	C_6H_{14}	0.0002	86.17	0.02
		1.0000		18.97÷28.9=0.656 sp. gr.

(Continued from Page 82A)

the chart. Most meter manufacturers recommend that the two seal pots be on the same level, but if not on exactly the same level, correction can be made by adjusting the differential pen to the correct zero position while the meter is under operating pressure.

Fig. 1. The portion of the basic supercompressibility curve covering the operating range has been enlarged for greater accuracy



Consider the typical analyses of raw and residue gas at a high-pressure cycling plant as shown in Table 1.

The total of column 4 for each gas in Table 1 gives the average molecular weight of the sample, which divided by the molecular weight of air (28.9) gives the specific gravity of the sample.

The computations to determine the pseudo-critical temperature and pressure of the raw gas are shown in Table 2.

For 120°F. flowing temperature or 580°F. absolute temperature, the pseudo-reduced temperature would be

$$\frac{580}{402.2} = 1.442 = T_r \text{ for the raw gas.}$$

For 1800 lb. per sq. in. gauge pressure or 1814.4 lb. absolute pressure, the pseudo-reduced pressure would be

$$\frac{1814.4}{663.9} = 2.733 = P_r \text{ for the raw gas.}$$

Using T_r and P_r as thus determined, the supercompressibility factor from Brown's curve[4] would be 0.7475=Z. The corresponding factor for correcting orifice meter volumes (F_{pv} in A.G.A. Committee Report No. 2) would be:

$$\frac{1}{\sqrt{0.7475}} = 1.1566 = F_{pv}.$$

It was found that interpolation for Z values between curves on Brown's curve was difficult and that it covered a wider range of T_r and P_r values than needed. A small portion of this curve was therefore enlarged and intermediate curves interpolated with the result as shown in Fig. 1. The values of Z can be read more rapidly and accurately from Fig. 1.

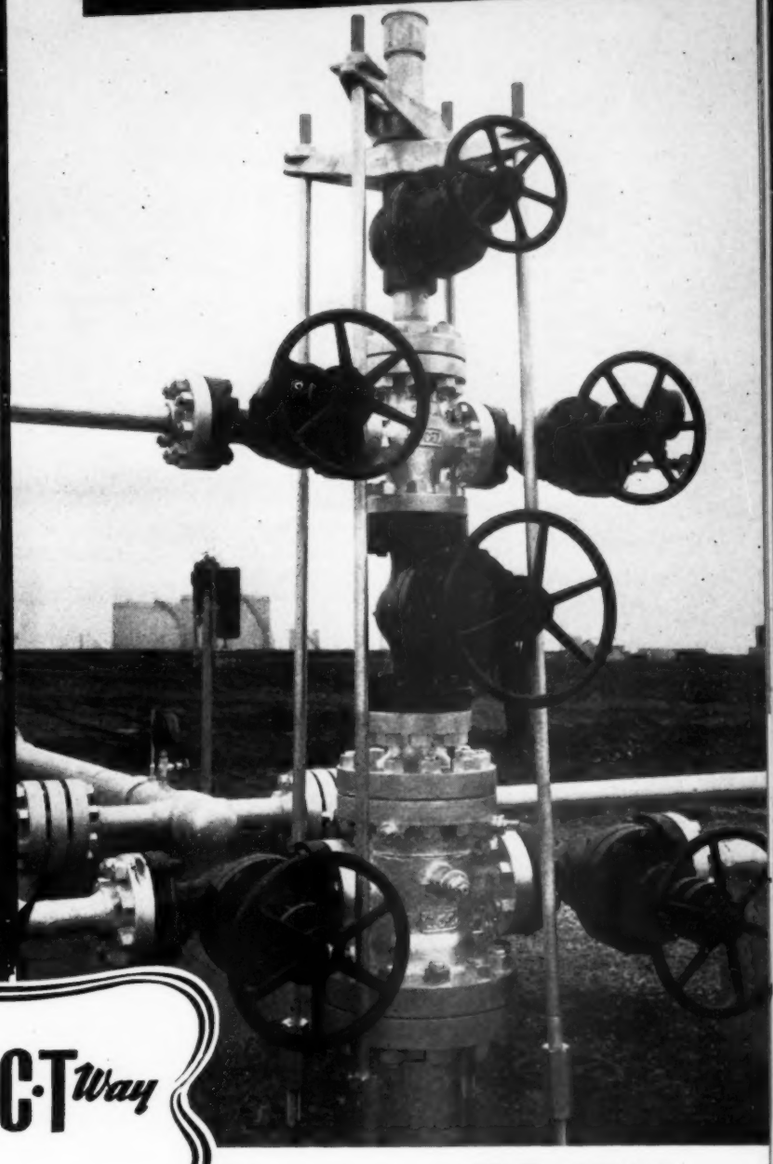
Calculation of orifice meter factors for the raw gas sample at 120°F. flowing temperature and gauge pressures of 1800, 1900, 2000, 2100, and 2200 lb. per sq. in. are shown in Table 3.

Orifice meter supercompressibility factors for both raw gas and residue gas were calculated as in Table 3 for the range of temperature and pressure encountered and curves plotted as shown in Fig. 2. It was noticed that flowing temperature factors (F_t in A.G.A. Committee Report No. 2) partly offset the supercompressibility factors and curves were drawn covering combined flowing temperature and supercompressibility factors (supercompressibility factor multiplied by flowing temperature factor), as shown in Fig. 3. It will be noticed from Fig. 3 that the flowing temperature factor completely cancels the supercompressibility factor in the residue gas at cer-

[4]See Fig. 4, *loc. cit.*

DRILL 'EM ...Safely!

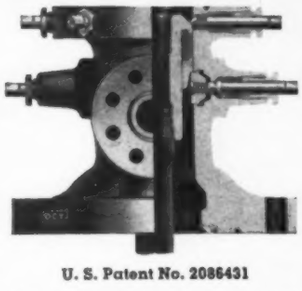
COMPLETE 'EM ...Safely!



The O-C-T Way

U. S. Patent No. 1997152

Look under the derrick floors of the drilling rigs in proven high pressure or wildcat areas and you'll see O-C-T Blowout Preventers on a large number of the drilling control hook-ups. O-C-T Preventers, used in conjunction with ram type preventers, provide an all-important secondary seal and relieve the ram packers of wear caused by rotating and raising and lowering drill pipe to prevent sticking while subduing kicking pressures. Well pressure forces the pack-off to seal around the pipe . . . the higher the well pressure, the tighter the seal. The O-C-T pack-off may be replaced quickly and economically when worn out. A stripper type pack-off, which permits running and pulling pipe under pressure, readily interchanges with the regular pack-off in all O-C-T Preventers.



U. S. Patent No. 2086431

Throughout the Mid-Continent and Gulf Coast high pressure areas, the fields are dotted with O-C-T Chrismas trees . . . undeniable proof of the extra measure of quality built into this equipment. There are literally dozens of different types of O-C-T Tubing Heads available for Christmas tree foundations. Type T-26, shown on the Christmas tree above and in cross-section herewith, is one of the most popular tubing heads built. Having retractable hanger seats, it permits running and landing tubing under pressure *through both screwed and flanged blowout preventers.* As shown in the accompanying cross-section drawing, the O.D. of the tubing hanger is slightly smaller than the I.D. of the casing above which it is used.

Write for fully descriptive literature.

OIL CENTER TOOL CO.
QUALITY O-C-T PRODUCTS
HOUSTON, TEXAS. U·S·A

Export Representative: Val R. Wittich, Jr.,
30 Rockefeller Plaza, New York, N. Y.

Selling Through Leading Supply Stores

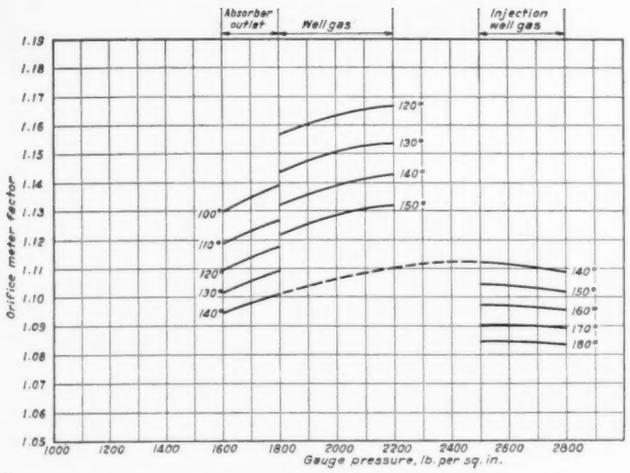


Fig. 2. Supercompressibility factors

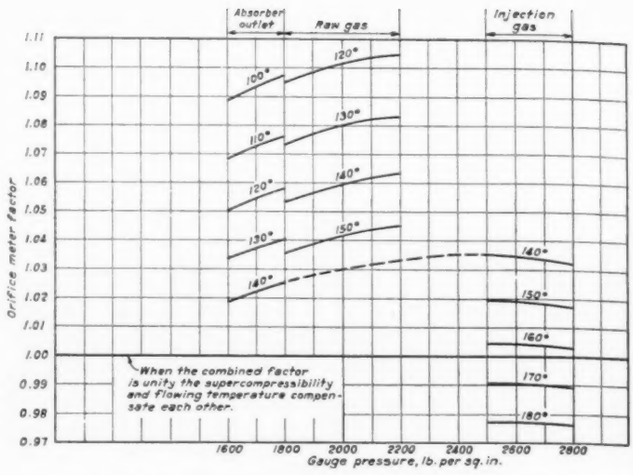

Absorber outlet
Raw gas
Injection gas
Orifice meter factor
Gauge pressure, lb. per sq. in.
When the combined factor is unity the supercompressibility and flowing temperature compensate each other.

Fig. 3. Combined supercompressibility and flowing temperature factors

tain temperature and pressure values. Curves for "Absorber Outlet" and "Injection Well Gas" are based on residue gas, but at different pressure ranges.

Operating pressures and temperatures tend to remain fairly constant in cycling plant operation and percentages of different constituents in the gas as determined by analysis usually change very slowly as the plant becomes older. Curves can therefore be prepared covering orifice meter supercompressibility factors as shown in Figs. 2 and 3 about once every 6 months or as often as analysis shows sufficient change in constituents of the gas.

TABLE 2

(1) Component	(2) Fraction	(3) Individual critical temperature	(4) (2)×(3) Absolute pseudo-critical temperature	(5) Individual critical pressure	(6) (2)×(5) Absolute pseudo-critical pressure
CH_4	0.8185	344	281.6	673	550.9
C_2H_6	0.0829	549	45.5	712	59.0
C_3H_8	0.0432	666	28.8	617	26.7
iC_4H_{10}	0.0069	732	5.1	544	3.8
nC_4H_{10}	0.0157	766	12.0	551	8.7
C_5H_{12}	0.0112	846	9.5	485	5.4
C_6H_{14}	0.0216	914	19.7	435	9.4
	1.0000		402.2		663.9

TABLE 3
Well gas at 120°F.

(1) Lb. per sq. in. absolute	(2) Pseudo-critical pressure	(3) (1)÷(2) P_r	(4) T_r	(5) (Fig. 1) Z	(6) $\sqrt{Z}$	(7) (Factor) $\frac{1}{\sqrt{Z}}$
1814.4	663.9	2.733	1.442	0.7475	0.8646	1.1566
1914.4	663.9	2.884	1.442	0.7425	0.8617	1.1605
2014.4	663.9	3.034	1.442	0.7385	0.8594	1.1636
2114.4	663.9	3.185	1.442	0.7365	0.8582	1.1652
2214.4	663.9	3.335	1.442	0.7350	0.8573	1.1665

Given the following conditions:

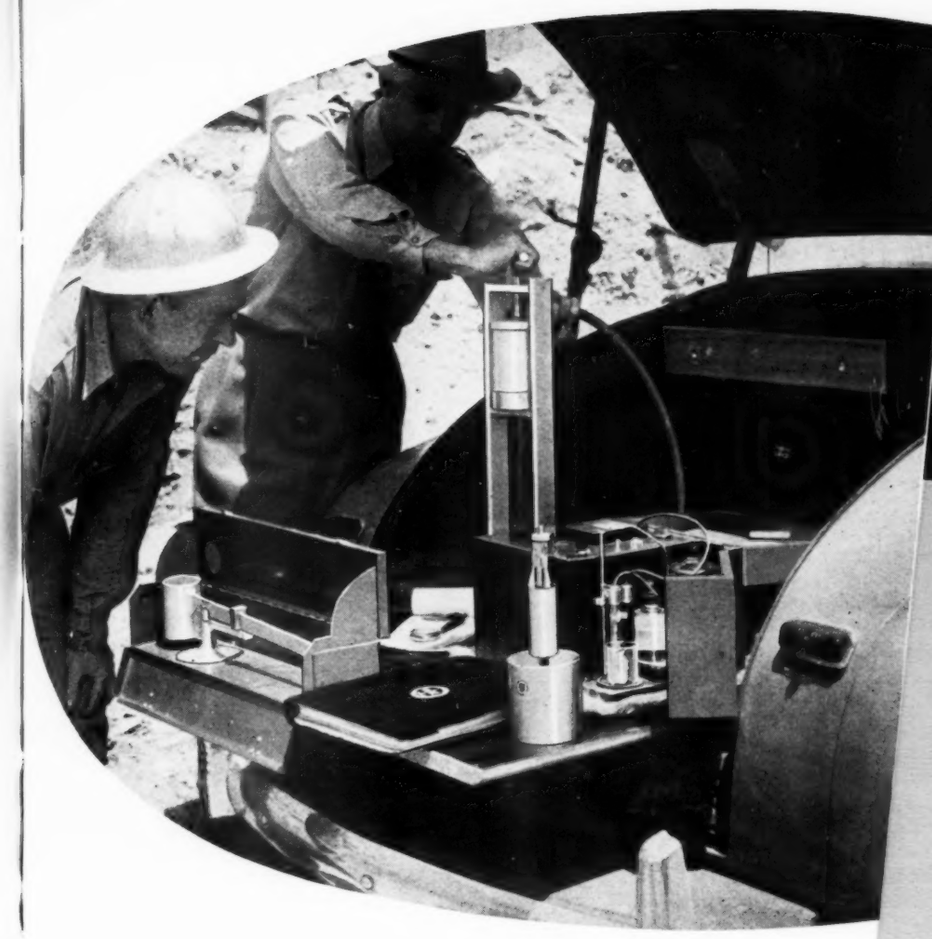
Raw gas sample as in Table 1	
Internal pipe diameter (6 in. XXH), in.	4.897
Orifice diameter, in.	2.000
Contract pressure base (4 oz. above 14.4)	14.65 lb. per sq. in. abs.
Specific gravity (as calculated in Table 1)	0.744
Flowing temperature	130°F.
Static pressure on meter	1800 lb. per sq. in. ga.
Recorded differential on meter	60 in. water pressure
Average atmospheric pressure	14.4 lb. per sq. in.
Basic coefficient[3](14.4 lb.—60°F.—1.0 sp. gr.)	843.02
Pressure base factor	0.9829 = (14.4 ÷ 14.65)
Specific gravity factor	1.1625 = ($\sqrt{1 \div 0.744}$)
Combined Fpv and Ft factor at 1800 lb. and 130°F	1.074 (Fig. 3)
Liquid seal factor	0.9625 (For water seal pots)
Corrected hourly coefficient	995.7
Static pressure multiplier	42.6 = ($\sqrt{1800+14.4}$)
Differential multiplier	7.75 = ($\sqrt{60}$)
Net gas flow per hr.	329,000 cu. ft.

The factors from Fig. 2 or Fig. 3 based on average temperature and pressure can be incorporated in the meter coefficient if temperature and pressure of gas at the meter remain fairly constant. For varying temperatures and pressures the factors can be applied to metered volumes daily or monthly as desired. If factors from Fig. 2 are used, an additional factor for flowing temperature must be applied, tables for which are available in all orifice meter handbooks.

In the lower left-hand corner of this page is a sample calculation of the flow through a high-pressure meter measuring gas to a cycling plant.

Calculation of flow through a meter measuring residue gas and not equipped with seal pots would involve all factors above except the liquid seal factor. All measurement departments have "extension tables" from which combined static pressure and differential pressure multipliers can be obtained, and many are equipped with a chart integrator on which the total of the hourly "extensions" for each chart are computed. The two multipliers are listed separately in the above calculation to show the mathematical basis for each.

The writer wishes to express thanks to those who have contributed data previously published on the subject that has formed the basis for this discussion.



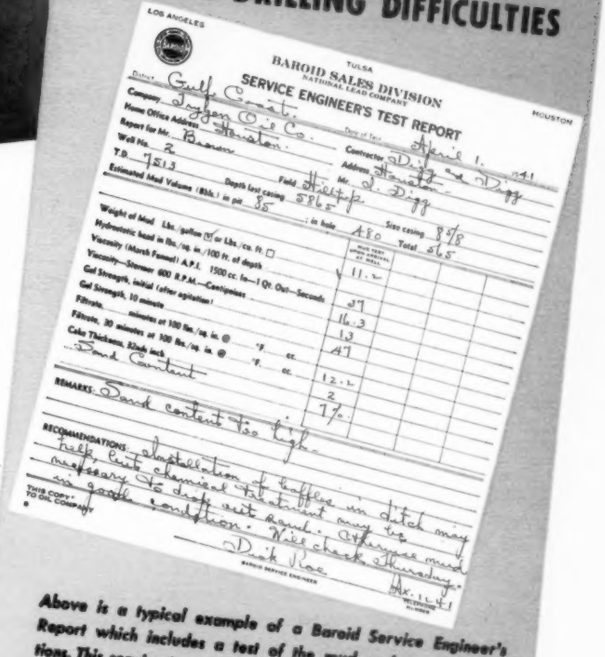
Specialists in MUD CONTROL

BAROID SERVICE ENGINEERS AND BAROID PRODUCTS HELP REDUCE OVER-ALL DRILLING COSTS BY MINIMIZING DRILLING DIFFICULTIES

Field results are not always exactly comparable to laboratory experiments. Baroid Service Engineers are not only laboratory trained men, but they are experienced in actual drilling mud servicing.

The accumulated knowledge gained by this company in mud servicing—not in one field but in most of the oil fields of the United States and many foreign fields—is available to Baroid Service Engineers as a guide in making recommendations, and for minimizing drilling difficulties. Accurate tests to determine the performance characteristics of the mud are made right at the well. To make these tests, Baroid Service Cars are completely fitted with all necessary equipment.

Baroid Service Engineers and Baroid Products have helped to eliminate drilling troubles and reduce over-all drilling costs in thousands of wells. Both are available in all active oil fields of the United States.



LOS ANGELES — TULSA — HOUSTON

BAROID SALES DIVISION
NATIONAL LEAD COMPANY

SERVICE ENGINEER'S TEST REPORT

District Gulf Coast
Company Ingram Oil Co.
Home Office Address
Report for Mr. Winston
Well No. 2
T.D. 7513
Estimated Mud Volume (Bbls.) in pit 85
Depth last casing 5865
Contractor Driscoll Drlg.
Address
Field Hollyp
Sec. 2 Twp.
Size casing 8 5/8
Total 865

Weight of Mud: Lbs. gallon (*) or Lbs./cu. ft. (□)					
Hydrostatic head in lbs./sq. in./100 ft. of depth					
Viscosity (Marsh Funnel) A.P.I. 1500 cc. In—1 Qt. Out—Seconds	11.4				
Viscosity—Stormer: 600 R.P.M.—Centipoises					
Gel Strength, initial (after agitation)	37				
Gel Strength, 10 minute	16.3				
Filtrate, minutes at 100 lbs./sq. in. @ °F. cc.	13				
Filtrate, 30 minutes at 100 lbs./sq. in. @ °F. cc.	47				
Cake Thickness, 32nds inch					
Sand Content	12.4				
	2				
	1/				

REMARKS: Sand content too high.

RECOMMENDATIONS: Dilution & settling in ditch may help. Put chemical treatment away to be necessary to drop out sand. Difficult mud on good condition. Will check Thursday.

Dick Noe
BAROID SERVICE ENGINEER

TYPE COPY TO OIL COMPANY

Above is a typical example of a Baroid Service Engineer's Report which includes a test of the mud, and recommendations. This service is available at no cost to the operator.

PATENT LICENSES, unrestricted as to sources of supply of materials but on royalty bases, will be granted to responsible oil companies and operators to practice the inventions of any and/or all of United States Patents Nos. 1,575,944; 1,575,945; 1,807,082 and 1,991,637 and further improvements thereof. Applications for such licenses should be made to the Los Angeles office.

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AQUAGEL—Gel-Forming Colloidal Drilling Clay.
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STABILITE—A Chemical Mud Thinner.
AQUAGEL-CEMENT—For Recovering Lost Circulation and Cementing Casing.
SMENTOX—For Counteracting the Effects of Cement Contamination and for Reconditioning Cement-Cut Mud.
ZEOGEL—Used as a Suspending Agent When High Concentrations of Salt or Salt Water Are Encountered.
IMPERMEX — A Concentrated Colloidal Additive Agent for Reducing Water Loss in Salt-Laden Muds.
MICATEX—For Reducing Water Loss to the Formation and for Overcoming Mild Cases of Lost Circulation.
TESTING EQUIPMENT—For Drilling Mud Analysis and Control.
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TRADEMARK BAROID OIL WELL DRILLING MUD SERVICE

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California Practice In Casing Deep Wells

PETROLEUM ENGINEER Exclusive Feature

☆ Long strings are "tailor-made" and special joint designs are used extensively

by Wallace A. Sawdon

Pacific Coast and Foreign Editor

LONG casing strings for deep wells are becoming to an ever-increasing extent "tailor-made." This means that for a predetermined outside diameter the string is made up of pipe with different wall thicknesses and different physical properties of steel to provide maximum economy and necessary safety. Developments in metallurgy and joint design have kept pace with the requirements of deep wells in California but operators, with the coöperation of pipe manufacturers, are still progressing in the science of pipe selection. The new grades of steel have proved their advantage in making-up long strings. The great variety of sizes and weights now being supplied by the manufacturers to meet the needs of operators in California as well as in other states have, however, been a probable source of additional casing costs.

Recognizing the fact that additional costs attend the wide range in sizes, weights, and grades of pipe, the A.P.I. Committee on the Standardization of Oil Country Tubular Goods is now compiling a simplification of the recognized casing list. No definite report on this work can be made at the present time but the proposed tentative list will, when finally adopted, probably contain less than half the items included in the present A.P.I. Casing List. Regarding wall thickness, the new list will extend the range upward in strength for deep drilling and downward in weight for shallow drilling. With respect to pipe diameter, it will extend the size downward for slim-hole drilling and, although it will omit few present sizes, it will eliminate various weights and grades of a number of sizes to avoid duplication, or virtual duplication, of several items.

Present casing practice, however, is, of course, based on existing specifications that, from a strictly utility standpoint, seem to be fully adequate to meet requirements of the deepest wells now being drilled. The longest string yet run in California was 13,100 ft. of 7-in. in a well in the Wasco field. The casing programs of wells recently completed below 10,000 ft. in various fields of the state are shown graphically in Fig. 1. These all exceed the setting depths for Grade N-80 pipe as shown in Fig. 2 with the factor of safety indicated on the graph for collapse and tension. In some cases the strings are made-up of pipe of greater strength and/or greater wall thickness than specified in the A.P.I. listings; but in all cases the strings are floated-in and cemented with great care. It is the practice to use cement in sufficient amount to insure an adequate column behind the pipe and it is assumed that this cement encasement so reinforces the casing that it will reduce the hazard of collapse in those cases where the factor of safety of 2 is materially reduced by depth of setting.

Although A.P.I. Grade N-80 casing is used to obtain strength against collapse and high tensile strength, a considerable amount of Grade J-55 pipe is employed in making-up most of the long strings. The physical properties of the A.P.I. specifications are given in Table 1, which includes Grade H-40, of which surface strings usually consist.

Many of the long strings now being run are "tailor-made" to fit the specific well conditions. Many of these strings are made-up with a bottom section of N-80 pipe, a middle section of J-55 pipe, and a top section of N-80. No definite ratio of N-80 and J-55 pipe can be stated but the average will probably be about 50 percent of each, whether the J-55 is on top or in the middle. By placing the N-80 on the bottom of the string the greater strength is used against collapse; by placing the N-80 on top the greatest tensile strength is obtained where most needed.

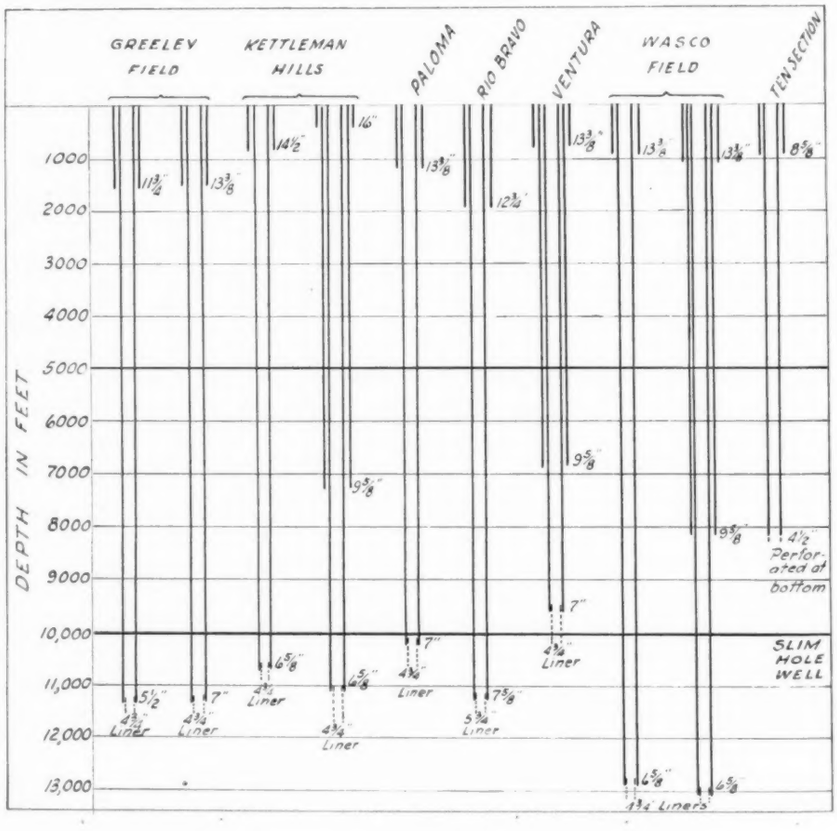


Fig. 1. Typical casing programs in California fields

BAASH-ROSS News

PETROLEUM ENGINEER EDITION

BAASH-ROSS TOOL COMPANY · LOS ANGELES · HOUSTON · NEW YORK

A MONTHLY BULLETIN COVERING NEWS OF EQUIPMENT AND OPERATIONS IN THE PETROLEUM INDUSTRY

CARE AND "FEEDING" OF DRILL PIPE

Some cost-cutting ways of handling drill pipe on the rig . . .

GO EASY on the weight. Authorities say too fast pipe feed can actually result in making *less* hole—and also tends to aggravate any weaknesses in the string.

B A A S H - R O S S

CIRCUMFERENTIAL cuts on drill pipe and concentration stresses can be avoided by using only rotary slips with non-continuous tooth patterns. You'll find that both Baash-Ross "Self-Aligning" and Baash-Ross "Unitized" Slips conform to this recommendation . . . and safeguard your drill pipe in many other ways as well.

B A A S H - R O S S

KEEP A FILE HANDY *to remove any slight burrs extending into the shoulder of either tool joint pin or box. This will assure complete joint make-up—a vitally important point.*

B A A S H - R O S S

DON'T TAKE A CHANCE with thin joints—or thin couplings. Lay them down out of the string as soon as discovered. Like the well-known chain, your drill string is no stronger than the weakest joint . . . and thin joints or couplings are trouble-makers.

B A A S H - R O S S

"FIVE TIERS HIGH" is a good general rule for maximum height at which pipe should be stacked on the rig. Any higher makes handling both difficult and unsafe—and can cause serious damage to pipe if doubles get out of control.

Something to Think About...

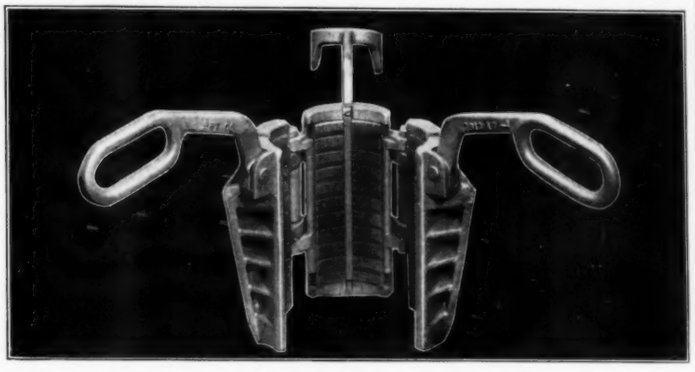
For years we've been doing our bit to help the oil industry develop . . . and we've seen it sprout and grow in all directions. We've read where there were twenty—then thirty—then *forty* million motor vehicles hustling people and products over the world's highways. We've read where there were tens of thousands of airplanes jumping from here to there and back again. We've read of the millions of gallons of fuel oil used by steamships and railroads in making the world's goods more readily available. We've read of the thousands and thousands of miles of highways paved with oil's by-product, asphalt. We've read of the synthetic rubber and glycerine and hundreds of other useful products being produced from oil. And we've thought, "Golly, it must take a lot of oil to do all these things."

Then the other day we ran across an authoritative report in which was mentioned this fact . . .

that all of the crude oil produced by all of the wells in the entire world since the very foundation of the oil industry would not fill a hole a cubic mile in size!

That's something to think about—and be proud of . . . that we are all part of an industry that has developed ways to contribute so much to the world's progress in so many different fields—from so comparatively little!

THE BAASH-ROSS TYPE "CU" ROTARY SLIPS



Unitized—the body sections always set at the same level around the pipe. Protects pipe against marking and crimping. Unique hinge permits lateral adjustment.

A COMMON CAUSE OF DRILL PIPE FAILURE AND HOW TO CORRECT IT

A recent engineering report emphasizes the point that slips play a vitally important part in the life of drill pipe. In modern high-speed drilling, it is not necessary for the pipe to be "chewed" with slip marks before there is danger of stress concentration damage setting in. Often the mark caused by setting a single slip too high or too low in the bushing *just once* is sufficient to start the destructive cycle that leads to costly pipe failure.

The unretouched photograph at right tells the story. Notice the perfect imprint of the single slip face in the surface of the pipe? Such a mark is caused when one slip is not aligned perfectly with the others as they are set into the master bushing, thus causing a concentration of slip pressure that "marks" the pipe. The markings form stress concentration points . . . which lead to fatigue cracks . . . which, in this case, resulted in a washout. This operator was luckier than most because the damage was discovered before a complete twist-off had occurred, leading into costly and risky fishing work!

The best crew in the field is apt to get a slip misaligned now and then . . . *unless they're using Baash-Ross Type "CU" Rotary Slips.* But even a greenhorn can set these slips perfectly *every time* . . . because they're *unitized.* The separate segments are so hinged together that they maintain perfect *vertical* alignment—yet are free to automatically adjust themselves *laterally*—as they feed in around the pipe. This means absolutely uniform distribution of slip pressure at all points . . . and no "marking," or "crimping" of the pipe.

The lateral adjustment feature in the hinge pin mounting is an important Baash-Ross advancement, for it allows the slips to adjust themselves to a perfect fit *around* the pipe without getting out of alignment vertically. But this is not the *only* advancement Baash-Ross engineers have built into these slips . . . not by a jug full. Check these!

Light Weight: By skillful designing, every last ounce of unnecessary weight has been taken out of the "CU" Slips so that they are unusually light . . . yet not a bit of strength has been sacrificed. They are amply strong to support the *longest* drill strings with a generous safety margin. And they are balanced so that they handle like a feather . . . fast, smooth, efficiently.

Safety Handles: Notice the husky *safety* handles. The full loop protects the operator's hands from being caught against the rotary table should the elevators strike the handles.

Integral Liners: The liners are mounted in the slip body in such a way that they are practically an integral part of the body itself. *There are no bolts or pins to shear under load,* for all strains are transmitted directly to the body through large support shoulders. What's more, the liners are unusually easy and quick to change simply by removing a *single* liner retaining key.

The complete story on Baash-Ross Type "CU" Slips is told in Bulletin 2B, sent free on request.

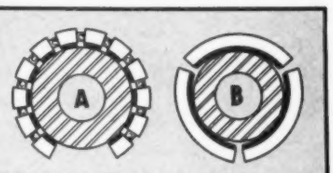
Flattened Toes: A good example of the attention Baash-Ross pays to "details" is the way the toe of each slip is flattened to form a solid surface upon which the slip stands firmly when placed on the rotary table or floor.

There are a lot more advanced features that Baash-Ross has incorporated in the Type "CU" Slips . . . so if you want to know what modern unitized slips can do toward stepping up the efficiency of your crews and cutting down drill pipe failures, ask your Baash-Ross representative to show you this equipment.

When you use this slip your drill collars won't

There's nothing in the field that will support drill collars in the table as safely and efficiently as Baash-Ross Drill Collar Slips. Their multi-segment body is flexible—*wraps* around the pipe like a chain tong and fits *every inch* of the circumference, whether it's round, out-of-round . . . new or worn.

This flexibility is important. Because drill collars—rotating as they do against the abrasive fresh-cut walls of the hole—lose diameter pretty rapidly.



Flexible multi-segment design of new Baash-Ross Drill Collar Slips (A) fits new *and worn* collars with equal efficiency. Rigid design of ordinary slips gives less grip as collar wears (B).

Rigid type slips can't adjust themselves to this loss of diameter—give less and less grip as the collar wears, until one day they fail to hold the collar in the table and you have a costly fishing job to wrestle with.

The Baash-Ross Drill Collar Slips, on the other hand, adjust themselves *automatically* to give the same full slip contact on new *or worn* collars—and will compensate for almost 5" reduction in the *circumference* (1½" in *diameter)* of the collar. No rig should be without a set of these slips—one of the *safest* safety investments you can make!

A new Bulletin — 13B — just printed gives you all the details about Baash-Ross Drill Collar Slips. Send for it!

Not in the cards

In case you ever want to drape the bull-wheel around the crown block—though why you *should* want to, we don't know—here's how one surprised drilling crew did it . . .

On a McKean County, Pennsylvania, well the crew was running tools back in the hole when the brake slipped off. The tools kept right on going—and at such a clip that the 1-ton bull-wheel was loosened from its moorings, carried clear to the top of the 57-foot rig . . . and stayed there!

Just another of life's little adventures that make nervous wrecks out of oil men.

In planning the string, different weights as well as different grades of pipe are generally employed to attain economy without reducing safety. An 8⅝-in. string just ordered, for example, consists of the following sections of pipe from the bottom up: 43-lb. N-80; 38-lb. N-80; 36-lb. N-80; 36-lb. J-55; 36-lb. N-80, and 43-lb. N-80. The upper section of 43-lb. N-80 pipe consisted of only two joints and was placed at the top of the string for landing in the slips of the landing head. This thicker pipe with its smaller I.D. also gives the minimum clearance for tools and insures that anything that will go through the top will go through the entire string without hanging-up.

A considerable amount of special casing is being used for long strings in California. The chief features of many of these makes of special casing are in the joint design or in the strength of the coupling material. The use of high tensile strength couplings allows a reduced O.D. with more clearance at the joint. The pipe itself is frequently made of a special alloy steel that may exceed A.P.I. specifications.

Certain special joint designs eliminate separate collars and have only one set of threads at each joint. One end of the joint is thus the pin end and the other the box end. These designs provide for speed in making-up and exceptionally fast running times have been made with types of casing employing joints following this design. As an example, 12,000 ft. of 7-in. casing was run in a well in the Wasco field in a total elapsed time of 8 hours, the string being floated-in in the usual manner. Faster running rates per hour have been made with shorter strings but the average rate under general conditions is probably less.

Special joints of the pin-and-box type have an O.D. less than that of A.P.I. casing couplings and are streamlined. External flush-joint casing, however, is generally used where clearances are small or where sloughing or caving formations are to be cased-off. Under certain conditions when the casing program employs three or more strings, flush-joint casing may be utilized to provide a saving in pipe cost by making it possible to run smaller pipe without sacrificing necessary clearance.

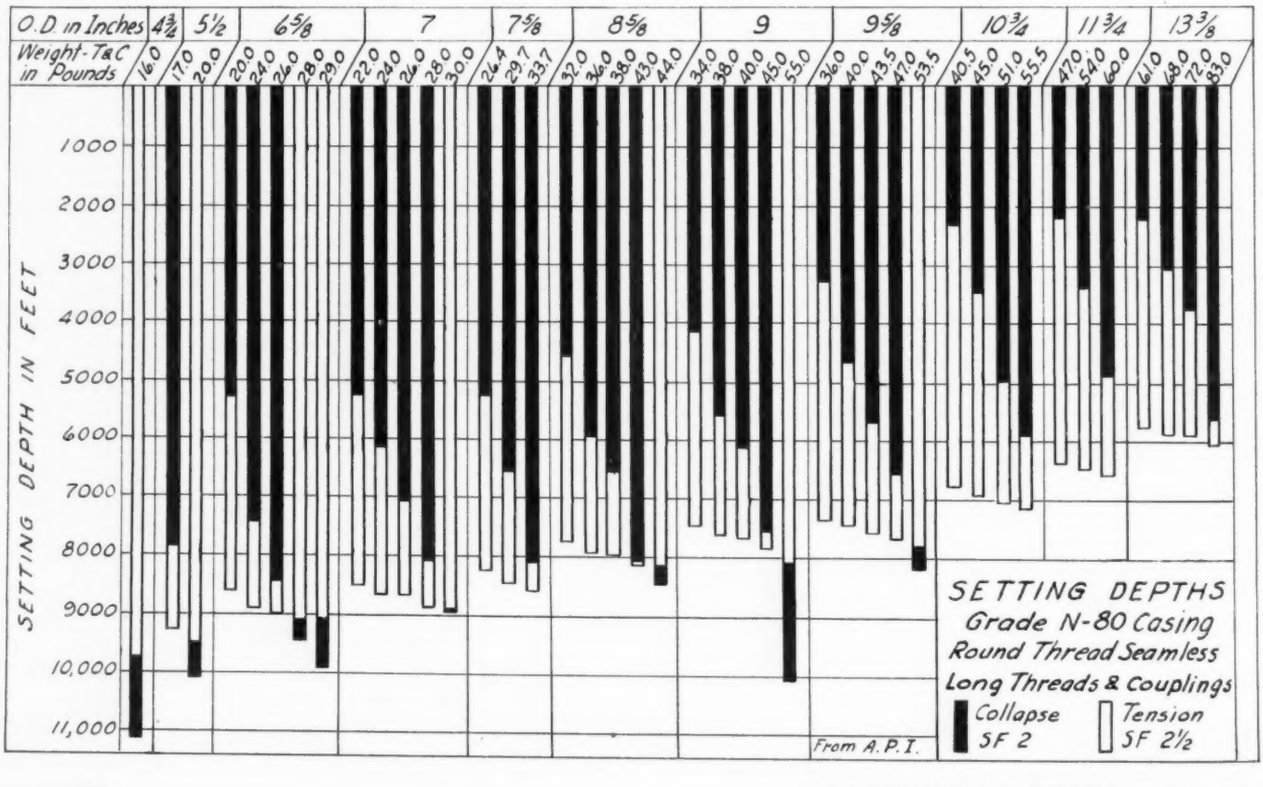
Landing and Cementing Casing

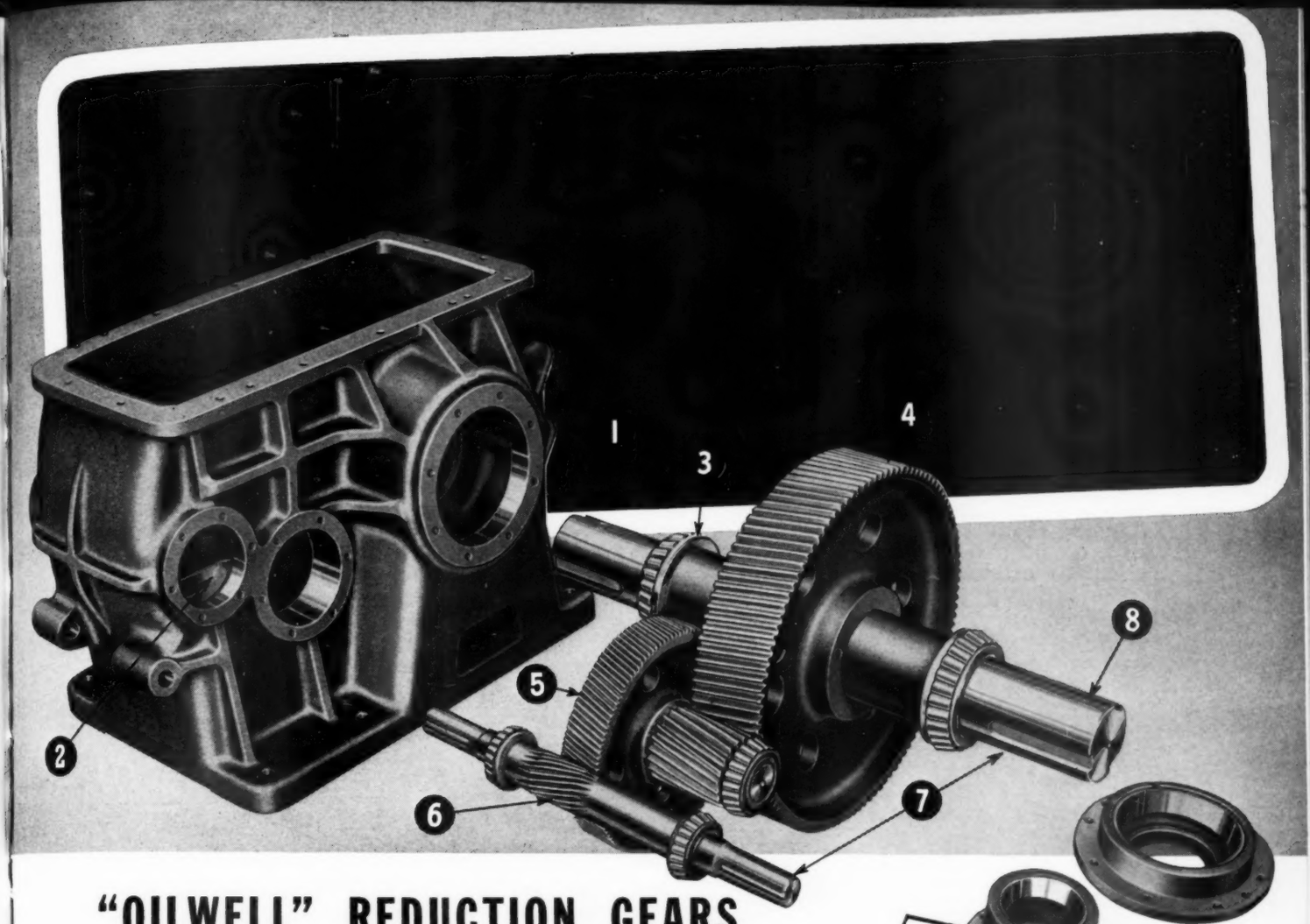
It is general practice in running long strings in deep wells in California to float them in with a float shoe on bottom and a float collar a joint or more above. The location of the float collar is determined by the preference of the operator and many believe that if the plugs are stopped one joint above bottom, enough tailings will be left in the casing to insure uncontaminated cement around the shoe. Others, however, prefer to place the float collar higher in order to leave more tailings in the pipe for added assurance that no poor cement reaches the shoe. In some cases the longest string is made-up with a float shoe and two float collars, one float collar being placed at the top of the bottom joint and the other at the top of the next joint above.

There is no uniformity in landing practice and the stretch taken on the casing in one district by one company may be different under similar circumstances from that taken in another district by the same company. There obviously must be a best way of determining the proper tension to impose on the pipe when landing a string in the landing head but the wide divergence of opinion concerning the amount of "stretch" indicates a more thorough study of the subject would be justified. In general, the present practice is to carry a load on the landing head something less than the weight of the string in air. This load has been ranging from 66 to 90 percent of the weight.

In determining the stretch to allow, consideration must be given to the fact that the string will weigh less in a hole full of mud, even with the inside full, and that after the string has been cemented the entire string is not hanging. Moreover, under some formation conditions the casing may not be free for some distance above the top of the cement and this will further shorten

Fig. 2. Chart to aid selection of proper weight casing





"OILWELL" REDUCTION GEARS

THE backbone of an "Oilwell" Pumping Unit is the precision-built, double-reduction gear. Here it is, spread out before your eyes, so you can see the "works." Strength and long life are built into every tooth and bearing. This simple, sturdy construction pays dividends in reduced maintenance long after the unit has earned its installed cost.

NOTE THESE FEATURES . . .

1. Symmetrically proportioned and heavily ribbed cast semi-steel case, providing a permanently rigid mounting for the bearings.

2. Constant and ample circulation of lubricating oil at all speeds through scientifically arranged troughs and passages — no wipers or other loose parts. Oil pockets at the bearings assure instant lubrication when starting.

3. Heavy-duty tapered roller bearings throughout—easily adjusted for wear, making it possible to maintain the original accurate alignment of the shafts.

4. Precision-hobbed, single-helical gears —harder steels are used and tooth-loading is uniform, resulting in greater strength and longer wear. No floating pinions required.

5. The low helix angle provides adequate tooth-overlap for quiet and efficient operation with less sliding contact, less side-thrust, less pumping action, less backlash and lower resulting impact stresses.

6. Full heat-treatment of gears and pinions prolongs wear-life. Pinions are integral with their fully heat-treated shafts.

7. High-speed and low-speed shafts are equally extended at both ends. Either right-hand or left-hand drive may be used. "Oilwell" reduction gears are designed for full power output from either low-speed shaft extension, making them especially adaptable to single-crank units and back-crank applications and providing an extra factor of safety for twin-crank units.

8. Three keyways in each low-speed shaft extension make it possible to change the crank positions and thus distribute wear evenly over the low-speed gear. Symmetrical design permits turning all shafts end-for-end to reverse tooth contact. Gears operate satisfactorily in either direction of rotation.

When you invest hard-earned dollars in a pumping unit, make sure that the reduction gear will guarantee long, efficient life. Send today for specifications of "Oilwell" units that will suit your particular needs.

OIL WELL SUPPLY COMPANY

the distance over which the stretch is effective. One suggestion has been made that the weight of the string before cementing, as read on the weight indicator, be noted and that this weight reading be used when setting the casing in the slips after the cement job is completed.

If too much tension is taken on the pipe the string will be too taut and the whipping of the drill pipe may cause it to break. Subsequent cooling may also cause additional stretch to a degree that the metal will fail. In one well, for example, a heavier gas flow than expected was encountered when drilling-in and after the production of the well declined the cooling effect from the expansion of the gas caused the pipe to part at the top joint. The stress at the point of highest tension should not be allowed to exceed 2/3 of the yield point of the pipe.

When the string is landed with insufficient stretch the casing will hang too loosely in the hole and may wobble during subsequent operations. There is then the hazard of the pipe breaking near the top of the string. The A.P.I. round threads now generally used withstand wobble, but when the wobble is excessive they will not prevent breaking at the coupling.

The long casing strings in California deep wells are usually cemented by the two-plug method although the bottom plug is frequently omitted and two plugs are sometimes placed at the top of the slurry. Mixing of the cement is done with the truck pumps but displacement of long strings when time is an important factor in getting the slurry behind the pipe at great depths is generally accomplished with the big volume mud pumps. The average amount of cement placed behind strings of 10,000 ft. and longer is now probably about 1500 sacks although as many as 2500 sacks have been used in some wells under normal conditions. The slurry used for these jobs ranges from 118 to 120 lb. per cu. ft. and has to the present time been made with oil-well cements.

The thickening rate of the cement is being given due consideration and speed of mixing and displacement has been speeded-up as much as possible. Bulk cementing has aided in mixing speed and the average at present is from 35 to 40 sacks per min. When mud pumps are employed to provide rapid displacement the cementing trucks remain hooked-up so that the pressure gauge on the truck can be used to indicate when the plugs bump.

Realizing that the mud cake may be detrimental to the effectiveness of the cement job, efforts have been made to utilize every reasonable means of removing the mud that is possibly present at the time the cement job is performed. Raising and lowering of the string during cementing has been employed for some time as a means of obtaining a better bond and preventing channeling higher up. When scratchers are used on the string to remove the cake this movement of the pipe is, of course, necessary if the scratchers are to do their job properly. The distance through which the casing is moved is frequently as great as 20 ft. and in some cases as much as 30 ft. One company moves the string upward and downward as fast as possible but all others move it slowly. Rotation of casing during cementing operations has not yet been tried in California although it has met with evident success in other areas.

Gel-cement is also used to some extent in cementing casing strings. One company precedes the main body of neat cement slurry with gel-cement and then follows the neat cement with another batch of gel-cement to complete the job. The purpose of the first batch of gel-cement is to push mud ahead of it and prevent contamination of the neat cement slurry, as it resists infiltration by any mud removed from the wall of the hole. The batch at the end of the job is used to provide a better bond at and above the shoe as water loss and shrinkage is less with the gel-cement.

Although surface strings are short they are definite factors in the casing programs of deep wells. It is to the top of the surface pipe that other strings are anchored through landing heads so the importance of the surface string is obvious. These strings are cemented completely from the shoe to the surface with the slurry usually pumped downward around the shoe. In some wells this method is used for the bottom part of the string and the top part is filled from the surface.

TABLE I

Physical properties of A.P.I. casing

(From Supplement No. 6 to A.P.I. Standards No. 5-A)

A.P.I. grade symbols	*Minimum strength*		*Minimum elongation,*
	Yield, lb. per sq. in.	*Tensile, lb. per sq. in.*	*percent in 2 in.*
N-80	80,000	100,000	16
J-55	55,000	75,000	20
H-40	40,000	60,000	27

P 951.1

Texas Oil Reserves Being Mapped

MORE than half the nation's estimated underground oil reserves are being charted by the University of Texas, with the assistance of the Works Progress Administration.

These supplies, confined in Texas rock structures and estimated at from nine to ten billion barrels, are being carefully mapped to show locations, depths, and geological formations.

Using technical data and drillers' logs from 190,000 wells, the survey will cover every one of the 254 counties in the state. A preliminary estimate showed that 176,000 written well logs had been kept from 1886 until the present time, and another 20,000 electrically plotted logs have been recorded since 1932. Of these many holes drilled by the oil industry, approximately 91,500 wells are now producing in the state.

The survey will locate not only known oil-bearing structures but will provide important data for drillers in search of new fields, and aid the search for supplies of water.

"Compilation of these facts and of these data will open another and broader field of study and research in stratigraphic geology in Texas," said Dr. R. H. Cuyler, assistant professor of the department of geology of the University of Texas, "and this is the first undertaking of its kind in the state."

The file will be available for use by students at the University, persons engaged in research, and others.

This vast collection of plotted drillers' logs and electrical logs of wells drilled for oil and gas will be cataloged in a card index system. A correlation of these logs will be accomplished by accepted methods of geological work, including cross-sectional maps and locations of formations as revealed on plotted logs.

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High tensile properties
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Top quality steel
Dimensional accuracy
Sizes up to 24" O.D.
Universal acceptance

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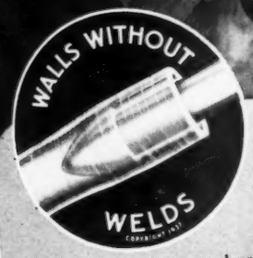
Successful operators agree, after long and wide experience, that there's no substitute for seamless—that the only way to get seamless advantages is to use seamless products. Since even the best geologists can't always predict with certainty what you may run into thousands of feet below the surface, it pays to use the best protection you can get against any conditions that might be encountered.

That's why NATIONAL Seamless Drill Pipe, Casing, and Tubing are today first choice with more successful oil and gas men than any other type of tubular goods. Continuous, uniformly high wall strength . . . strong, accurately made threads . . . proved ability to withstand unexpected stresses — these are qualities which account for the unsurpassed reputation of NATIONAL Seamless — "Walls Without Welds."



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P 425.
P 111.341.

Current Drilling Practice in the Texas Panhandle

PETROLEUM ENGINEER Exclusive Feature

☆ Lightweight rotary drilling equipment continues to increase in favor—experiments are being made with completing gas wells by rotary, using gas as circulating medium

by H. Lee Flood Associate Editor

DRILLING activity in the Texas Panhandle field is at a higher level at present than it has been for years and there is every indication that the number of new wells drilled may continue to increase during the summer months.

The recent discovery of oil in several outpost wells in the general vicinity of Pampa has supplied much of the spark needed to revive interest in drilling but this has not been the real incentive for operators to spend money for new wells.

It is generally agreed, although not universally, among Panhandle operators that relatively new types of lightweight portable rotary drilling and cable-tool spudding machines and the reductions in drilling time and well costs made possible through their use have "made the difference."

Low well allowables, uncertainty as to future prices for oil, and the many other economic considerations that confront all operators in all fields are perhaps more complex in the Panhandle than elsewhere. As of April 1, the posted prices of Panhandle crude oil were advanced 6 cents a bbl. for sweet oil and the 5 cents per bbl. penalty imposed against sour crude was eliminated. The latter change was particularly welcomed by those operators who were in the sour crude area as a relief from a situation they strongly believed was inequitable. In order to differentiate between sour and sweet crudes, a line had been drawn on the map and all oil produced on one side of the line was proclaimed sweet and all oil from the other side was called sour. Although this arbitrary line roughly defined the approximate boundary between the sweet and sour areas, in many instances oil that was as sweet as the sweet oil was classed as sour merely because it was produced "on the wrong side of the line."

Oil wells in the Panhandle district are presently produced under a 20-bbl. per day allowable with four shut-down days per month.

It is considerations such as these, involving the amount of oil that may be produced and the price that will be received for it that receive as much study in planning to drill a well as does the actual drilling itself.

It has been and probably will continue to be standard practice in the Panhandle to complete the wells with cable tools whether rotary or cable tools have been used to drill from the surface to set casing.

The two principal producing formations in the "Big Lime" are the dolomite series and the Granite wash. In both these formations, the bottom-hole pressures are extremely low and in the Granite wash the formation is so loosely consolidated that any fluid introduced into the hole will enter the formation so rapidly as to create a strong vacuum at the casinghead.

One of the principal topics of conversation among Panhandle drillers at the present time concerns the possibility of developing some method whereby rotary equipment may be used to complete the wells through the formation, thus eliminating the relatively costly "tailing-in" operation with cable tools.

One company has had fair success drilling into the dolomite with rotary, using the lightest weight mud possible and getting "in and out" of the formation as quickly as possible. Difficulty is usually encountered, however, after the formation is shot with explosives to open-up the relatively dense oölitic rock. If the hole can be completely bailed-out prior to the shot, removing all mud and water, and the shot tamped satisfactorily, it is believed the use of rotary may increase for drilling dolomite wells.

Another company has recently drilled a number of gas wells using rotary all the way and employing gas as the circulating medium to remove cuttings from the hole. This method is

Modern portable rigs are sturdy, dependable—ample capacity is provided for medium depth wells

"... TOTAL COST OF UNIT WILL BE PAID BACK OUT OF SAVINGS IN OPERATION THE FIRST YEAR."

Signal's New Well Servicing Unit Goes Into Action At Huntington Beach

EXACT REPRINT from a customer's House Organ

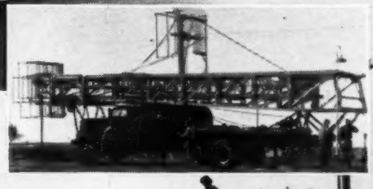
SIGNAL'S new oil well Servicing Unit now in operation at the Company's Bolsa Lease near Huntington Beach, California, is the first one of its kind to be used on the Pacific Coast. The new unit is simply a telescoping steel derrick and hoisting winch mounted permanently on a truck so that it can easily be moved from well to well for swabbing operations or pulling the pump rods and well tubing.

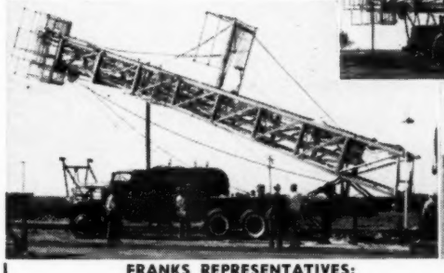
Last summer, on a visit to the International Petroleum Exposition in Tulsa, Oklahoma, Vice-President R. H. GREEN, Production Manager WALTER GREEN-FIELD and Chief Engineer G. L. YOUNG saw one of these units in actual operation on the Exposition grounds and decided that it was the answer to their problem of handling producing wells on the newly acquired Bolsa Lease. It meant to them the saving of considerable investment in steel derricks as well as lower labor cost in producing operations.

Results of observations indicate that the Servicing Unit can move from well to well in about thirty minutes, including time required to raise and lower the derrick and to move the truck into proper position. Another special feature of the Servicing Unit is the use of the truck motor for handling the derrick and hoisting winch as well as to supply power to all wheels under the truck for moving over the highway. When working at a well, the engine uses natural gas for fuel and when on the road, gasoline is used through a combination carburetor. It's expected that the total cost of the new Servicing Unit will be paid back to the Company out of savings made possible during the first year of operation on the Bolsa Lease.

See Composite Catalog or Write for Special Bulletin.

Right: Franks unit in telescoped position for moving. Below: Unit on location with derrick being raised.





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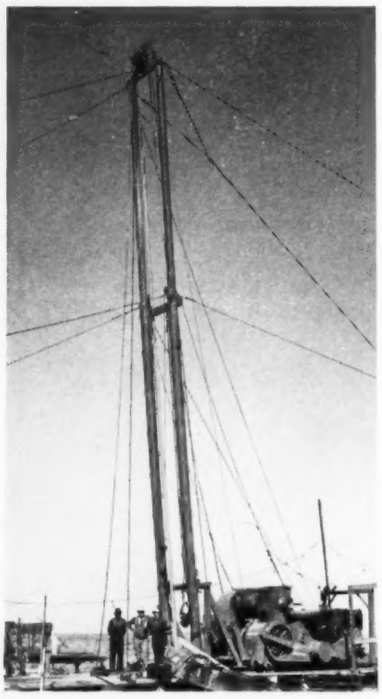


Spudders of this type drill-in after casing is set—often are used to drill the complete well

apparently satisfactory and may be adopted more widely in drilling gas wells despite the many objections to the method now being expressed. It is not believed that gas circulation can be made to apply in drilling oil wells, however.

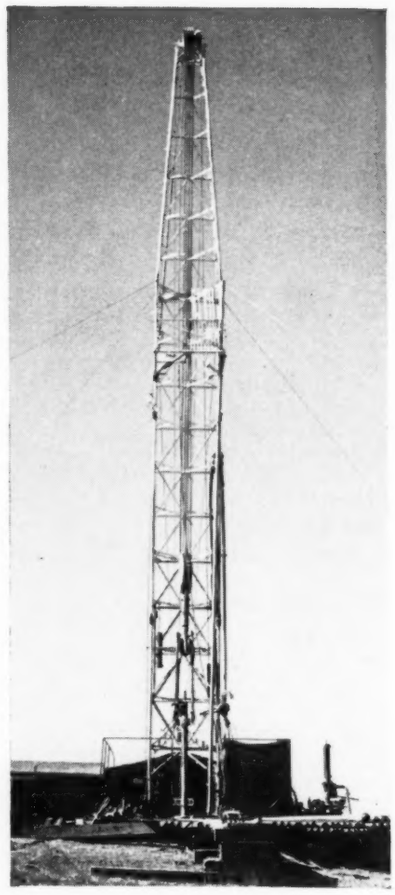
Thus far there is apparently no method whereby rotary can be used to complete oil wells, particularly in the Granite wash. It is possible that the present developments in California and elsewhere involving the use of chemicals to reduce surface tension and to dissolve mud and other plugging materials may eventually be effective as a solution for this problem of flooding the formation with mud and water.

Considerable difficulty has been encountered in drilling with rotary through shallow water sands in the east part of the Panhandle field. The extremely porous formations cause circulation to be lost and it is often with difficulty that the formation can be sealed-off. One contractor in the east field has had satisfactory results by drilling a few feet below the porous section as best he can, then filling the resulting rat-hole with a heavy mud to the base of the water sand. Cement slurry is dumped in the hole on the theory that it will float reasonably well on the mud and enter the pores of the sand under its own weight. This relatively simple procedure has apparently been successful but it is not known whether it would work under all conditions.

Nearly every type of light to medium-heavy drilling equipment is to be found in the Panhandle. There are still several steam rigs operating both rotary and cable tools but the tendency is to replace these machines with the newer portable rigs employing high speed engines. Diesel oil or natural gas are usually the fuels employed.

An analysis[1] of the cost of operating a light rotary rig of the portable rig, employing a three-man crew indicates

[1]Taken from the paper "Why Slim Hole Drilling?" by Carl White, Jr. Presented at the A.P.I. District Meeting at Pampa, Texas, April 8, 1940.

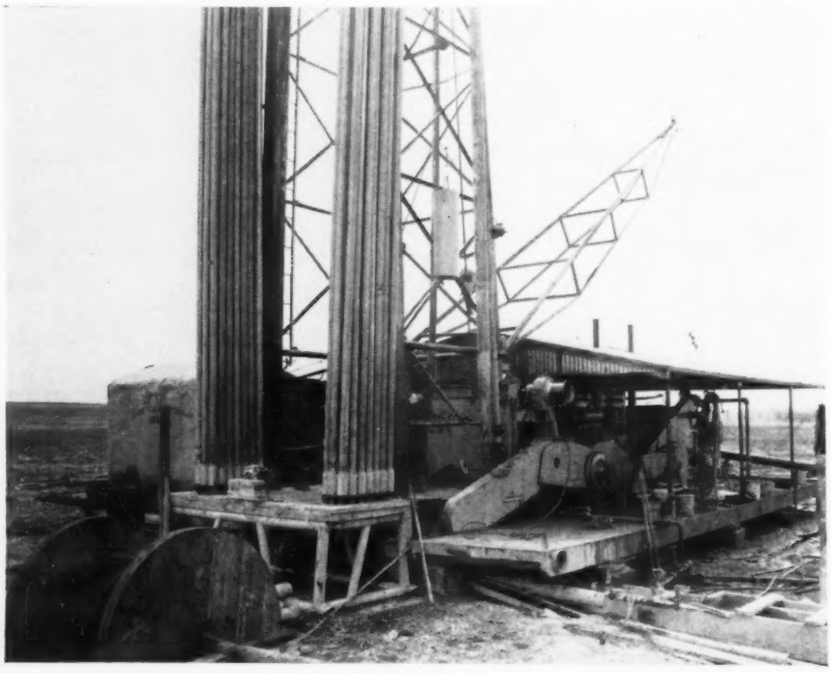


One of the portable mast type of light rotary equipment used in the Panhandle field

a monthly cost of $10,312, including a depreciation charge of 3½ percent per month on the rig. In the Pampa area, drilling three 3100-ft. wells per month, the unit cost of drilling is, therefore, $1.11 per ft. This compares favorably as an average with the $1.05 per ft. cost of one of the leading slim-hole operators in the Panhandle.

It is economical operation of this type that is proving the salvation of operators in shallow, low allowable fields.

There has been an increase in the amount of 4½-in. and 5-in. casing being run in Panhandle oil wells, thus effecting another reduction in well investment cost. There is considerable argument as to whether these smaller casings should be used in gas wells of the field. The belief that the smaller casing would adversely affect the open flow is not valid inasmuch as both the



This portable rig is powered with two engines compounded. Six hours is maximum time required to begin drilling after rig is on location

back-pressure and Pitot tube methods of calculating open flow take the casing size into consideration. Only in the extremely large gas wells of the area in which the 25 percent figure (representing the maximum withdrawal permitted) was considerable would the smaller casing penalize the operator.

In many of the gas wells in the field it is necessary to run a perforated liner through the 600- or 700-ft. gas sections that are interspersed with shale breaks. When a liner is anticipated or when a considerable amount of clean-out work is expected, the smaller casings are not desirable.

It is a coincidence in the Texas Panhandle that the water level in each porous formation occurs at or close to sea-level. Above the water level a zone of oil occurs and the upper portions of the anticlinal folds contain gas only. Consequently, it is only necessary for the porous horizon in a well to be encountered above sea-level to be productive of oil or gas. The amount of production then depends solely on the local porosity. "Perhaps nowhere in the world is there an area of comparable magnitude in which oil or gas operators may proceed with development with such assurance of success. In the oil- and gas-producing counties of the Texas Panhandle, the ratio of dry holes to producing wells is 1:15. . . . In the defined gas areas, the number of dry holes is practically negligible."[2]

The rock pressure is uniform in the Panhandle but is sub-normal, being less than half the normal hydrostatic head. The controlling factor determining this pressure anomaly is not definitely known. The decline in pressure from the initial rock pressure of 430 lb. per sq. in. for the field as a whole has been greatest in the areas developed for oil.

Oil was first discovered in the Texas Panhandle in 1925 and since then the area has been a major oil-producing district. The oil is produced principally from relatively small pools over a narrow 90-mile band lying along the north flank of the Amarillo Arch, principal geologic feature of the region.

At the present time there are approximately 125 drilling operations in the Panhandle, of which fully 100 are active. Some of the rigs being used to drill in the Panhandle, including one of the new type spudding machines used for drilling-in are shown in the accompanying photographs.

[2] "Geology and Occurrence of Natural Gas in Amarillo District, Texas," by Victor Cotner and H. E. Blum, in *Geology of Natural Gas, A Symposium*, edited by Henry A. Levy. Published by The American Association of Petroleum Geologists, Tulsa, Oklahoma, 1935.

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For quick reference turn to our section in the Composite Catalog. Your inquiries are invited.

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Program Natural Gasoline Association of America 20th Annual Convention, April 23-25, Dallas, Texas

THE program of the 20th Annual Convention of the Natural Gasoline Association of America, April 23, 24, and 25, Baker Hotel, Dallas, Texas, follows:

Wednesday, April 23

MORNING SESSION, 10:00 A.M.

"Revised Charcoal Testing Method"—H. L. Oder, Cities Service Oil Company, chairman, Gas Testing Committee.

(The method for determining the gasoline content of natural gas by the charcoal method has been completely rewritten to give more reproducible results. A report of committee work.)

"New Volume Correction Factors for Liquefied Petroleum Gases"—C. R. Williams, Continental Oil Company, chairman, Technical Committee.

(Replacing factors determined by extrapolation with those determined by laboratory experiments, this paper will review these studies together with several other projects of the Technical Committee.)

"The Magnitude of Variables Affecting Accurate Reid Vapor Pressure Determinations"—F. M. Allen, Indian Territory Illuminating Oil Company.

(Review of intensive research work on sources of error in these determinations and simple laboratory experiments graphically show the magnitude of these errors and how they may be eliminated. A research project of the Technical Committee.)

AFTERNOON SESSION, 2:00 P.M.

President's Address—George P. Bunn, Phillips Petroleum Company.

Address: "Natural Gasoline in National "Defense"—Elmer Schmidt, vice-president, Lone Star Gas Company.

"Useful Products from Natural Gas"—Dr. F. H. Dotterweich, Texas A. & I. College.

(A non-technical discussion of the increasing number of important products that the chemist is making from the hydrocarbons found in natural gas, and the general economics of this growing trend.)

Thursday, April 24

MORNING SESSION, 10:00 A.M.

"Safety in Handling, Shipping and Marketing of Liquefied Petroleum Gases"—G. L. Brennan, Philgas Division, Phillips Petroleum Company.

(A discussion of the best and approved methods of handling these products and pointing out the inherent dangers of certain prevalent distribution practices.)

"Low Temperature Fractional Analysis, Apparatus and Procedure"—C. E. Wharton and H. A. Montgomery, Hanlon-Buchanan, Inc.

(First public report of a standardization research project in which for more than a year 15 different laboratories of large companies have been running comparative analyses on identical gas samples. The results of these studies and the wide variation in equipment and procedure are of unusual interest.)

Presentation of Hanlon Award for meritorious service to the natural gasoline industry.

AFTERNOON SESSION, 2:00 P.M.

"Close Fractionation in the Manufacture of Special Products at Natural Gasoline Plants"—H. W. Harts, Warren Petroleum Corporation."

(The difficulties encountered in separating individual hydrocarbons with close boiling ranges to obtain relatively pure products. Reviewing the types and cost of equipment and the methods used by several companies in the manufacture of these products.)

Discussion of paper by J. L. Gallagher, Sinclair-Prairie Oil Company.

GEORGE P. BUNN, *President*

"Making Gas Measurements Balance in a Cycling Plant"—Don A. Sillers, Lone Star Gas Company.

(A discussion of the practical problems that confront the gas measurement man in the cycling plant, including freezing, the design of housing for meters, etc. Reference is also made to the orifice coefficients for thick wall pipe, and to the use of correction factors for compressibility and temperature.)

"Dehydration in High Pressure Gas Operations as Applied to Repressuring and Pressure Maintenance"—R. A. Carter, Continental Oil Company.

(Here is a paper of wide interest as it covers the broad experience of this company in solving the difficult problem of hydrate formation in high-pressure gas operations.)

Discussion of paper by Dr. G. G. Brown, University of Michigan.

EVENING, 6:30 P.M.

Buffet dinner and entertainment, Roof Garden, Baker Hotel—Compliments of the Natural Gasoline Supply Men's Association.

Friday, April 25

MORNING SESSION, 10:00 A.M.

"Operating Kinks" session in which field, plant, and laboratory men compete for substantial prizes with their own ideas for doing any job within their province in a safer, better or cheaper way. This session is a mine of information on unusual and practical methods of operation.

"Compressor Losses Caused by Orifice Meters"—V. E. Middlebrook and Jed Burnham, Shell Oil Company, Inc.

(With the master orifice meter upstream from the compressor, what are the losses in handling capacity and horsepower requirements? This paper answers these questions and proposes a simple solution to the problem.)

AFTERNOON SESSION, 2:00 P.M.

Continuation of "Kinks" session and discussions.

Presentation of Operating Kinks prizes.

J. R. JARVIS, *Vice-President*

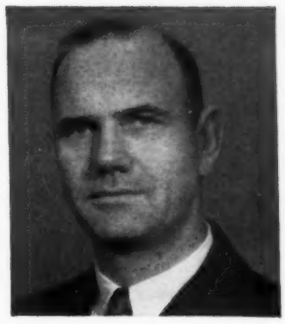
RAY E. MILLER, *Vice-President*

J. W. VAIDEN, *Vice-President*

WM. F. LOWE, *Sec'y-Treasurer*

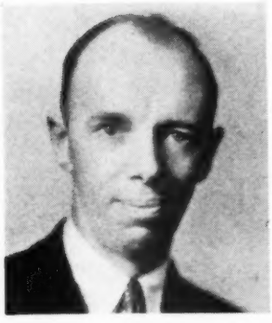
V. E. Middlebrook collaborates on a paper: "Compressor Losses Caused by Orifice Meters."

Jed Burnham collaborates on a paper: "Compressor Losses Caused by Orifice Meters."



Don A. Sillers presents a paper: "Making Gas Measurements Balance in a Cycling Plant."

R. A. Carter presents a paper: "Dehydration in High-Pressure Gas Operations as Applied to Repressuring and Pressure Maintenance."



H. W. Harts will discuss "Close Fractionation in the Manufacture of Special Products at Natural Gasoline Plants."

Elmer Schmidt will address the meeting on "Natural Gasoline in National Defense."

T. R. Goebel, Chairman, Program Committee.

G. L. Brennan presents a paper: "Safety in Handling, Shipping, and Marketing of Liquefied Petroleum Gases."

F. E. Fisher, member of the Program Committee.

Dr. George Granger Brown will discuss the paper delivered by R. A. Carter.

Dr. F. H. Dotterweich will present a paper: "Useful Products From Natural Gas."

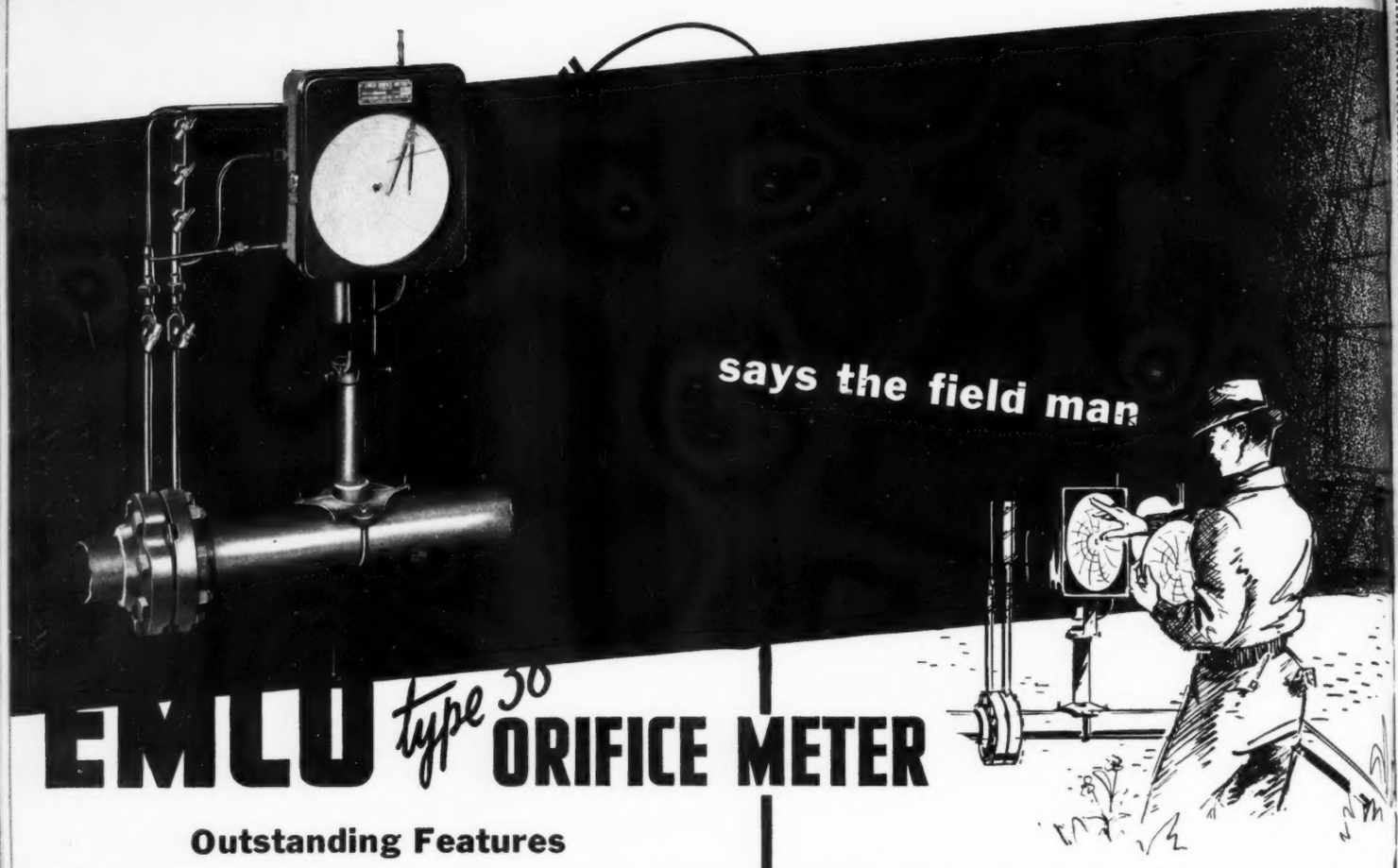
H. L. Oder will have as his subject: "Revised Charcoal Testing Method."

H. A. Montgomery, co-author of paper: "Low Temperature Fractional Analysis, Apparatus and Procedure."

H. H. Beeson, member Program Committee.

C. R. Williams presents paper: "New Volume Correction Factors for Liquefied Petroleum Gases."

C. E. Wharton, co-author of paper: "Low Temperature Fractional Analysis, Apparatus and Procedure."



EMCO *type 38* ORIFICE METER

Outstanding Features

DESIGN SIMPLICITY—Entire meter can be taken apart or built up with a 6" Crescent wrench and screwdriver.

FORGED STEEL MERCURY CHAMBERS AND DIFFERENTIAL HOUSING—Fabricated from high grade alloy steel forgings—eliminate porosity of castings, blow holes, and other possibilities of leaks or failure.

UNIT MANOMETER CONSTRUCTION—Quickly convertible from one pressure range to another

TIGHT SEATING CHECK VALVES—Most positive, reliable and easiest to service.

ALL-WEATHER, MOISTUREPROOF METER CASE—Fitted with heavy door hinges, quick acting, angular type door hasp. Baked enamel finish.

LONG HELICAL COIL TYPE STATIC PRESSURE ELEMENT—Especially developed for Orifice Meter measurement. Made from corrosion-resisting alloy and thoroughly aged to insure long life. Entirely accessible and fitted with two adjustments

EQUI-ANGULAR DIFFERENTIAL MOVEMENT—Eliminates the "angularity error" common to most previous types of meters. Is easy to remove for cleaning and inspection All parts are made of stainless steel.

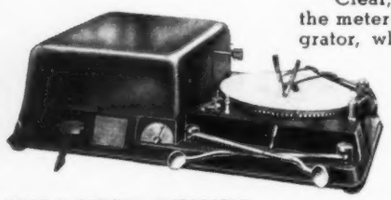
QUICKSET CHART HUB—Greatly simplifies changing charts. Unit construction eliminates possibility of lost or misplaced parts.

FULL CLOSING EQUI-FLOW DAMPENING VALVE—Provides equal resistance to mercury flow from either chamber Eliminates false readings, due to rapid change of flow.

STAINLESS STEEL PEN ARMS—Painted in different colors to readily distinguish between static and differential. Each arm quickly detachable and fitted with simple micrometer adjustment.

ALL-WELDED MANIFOLD—Eliminates numerous small leaks encountered in screwed piping. Made of high grade steel tubing for working pressures up to 4000 pounds.

THE EMCO SYSTEM OF MEASUREMENT BY ORIFICE



EMCO-McGAUGHY INTEGRATOR

The combination of EMCO Orifice Meters in the field with the EMCO-McGaughy Integrator in the office provides the ultimate in accuracy and convenience in measurement by the orifice principle.

Clear, legible charts accurately made by the meter are readily computed by the integrator, which mechanically calculates the chart records with speed and accuracy, thus eliminating the possibility of human error. This system of measurement furnishes machine precision in both recording and computing. It removes the intangibles from measurement by orifice.

THE eventual success of any mechanical instrument depends upon its ability to fully withstand field conditions. The supervision of equipment in the field requires personnel who must continually work under adverse circumstances in the exacting job of maintaining equipment in good operating condition.

In the design of the EMCO Type 38 Orifice Meter this particular phase has received special attention. Parts which normally require field attention, such as static pressure adjustments, pen adjustments, etc., are readily accessible, easily and fully adjustable with a minimum of effort. Only the simplest tools are required.

Routine tests and adjustments necessary for this type of measurement have been especially considered and the design evolved reduces to a minimum the time and effort required to maintain complete accuracy.

THE *Petroleum* Engineer's

CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 46

To aid the reader in using the Decimal system of filing, a subject index arranged alphabetically has been published, and is available at a cost of 50 cents per copy from *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

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Velocity of fluid through annulus between 6⅝-in. drill pipe and open hole, ft. per sec. (sheet 1)	P 425.218.150.66	65	July
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VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 1½-IN. AND 3½-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	300	3.8	1.5	0.9	0.7	0.6	0.5	0.4	0.4	0.3
100		7.7	3.0	1.9	1.4	1.1	0.9	0.8	0.7	0.7
150		11.5	4.4	2.8	2.1	1.7	1.4	1.2	1.1	1.0
200		15.3	5.9	3.7	2.8	2.2	1.9	1.6	1.5	1.3
250		19.1	7.4	4.7	3.5	2.8	2.4	2.1	1.8	1.7
300		23.0	8.9	5.6	4.2	3.4	2.8	2.5	2.2	2.0
350		26.8	10.4	6.6	4.9	3.9	3.3	2.9	2.6	2.3
400		30.6	11.8	7.5	5.6	4.5	3.8	3.3	2.9	2.7
50	400	5.1	1.9	1.2	0.9	0.7	0.6	0.5	0.5	0.4
100		10.2	3.9	2.5	1.8	1.4	1.2	1.1	0.9	0.8
150		15.3	5.8	3.7	2.7	2.2	1.8	1.6	1.4	1.3
200		20.3	7.8	4.9	3.6	2.9	2.4	2.1	1.9	1.7
250		25.4	9.7	6.1	4.5	3.6	3.0	2.6	2.3	2.1
300		30.5	11.7	7.4	5.4	4.3	3.6	3.2	2.8	2.5
350		35.6	13.6	8.6	6.3	5.1	4.2	3.7	3.3	2.9
400		40.6	15.6	9.8	7.2	5.8	4.9	4.2	3.7	3.4
50	500	6.3	2.4	1.5	1.1	0.9	0.7	0.6	0.6	0.5
100		12.7	4.8	3.0	2.2	1.8	1.5	1.3	1.1	1.0
150		19.0	7.3	4.5	3.3	2.7	2.2	1.9	1.7	1.5
200		25.3	9.7	6.1	4.5	3.5	3.0	2.6	2.3	2.0
250		31.6	12.1	7.6	5.6	4.4	3.7	3.2	2.8	2.5
300		38.0	14.5	9.1	6.7	5.3	4.4	3.8	3.4	3.0
350		44.3	17.0	10.6	7.8	6.2	5.2	4.5	4.0	3.6
400		50.6	19.3	12.1	8.9	7.1	5.9	5.1	4.5	4.0
50	600	7.6	2.9	1.8	1.3	1.1	0.9	0.8	0.7	0.6
100		15.2	5.8	3.6	2.6	2.1	1.8	1.5	1.3	1.2
150		22.7	8.7	5.4	4.0	3.2	2.6	2.3	2.0	1.8
200		30.3	11.6	7.2	5.3	4.2	3.5	3.0	2.7	2.4
250		37.9	14.4	9.0	6.6	5.3	4.4	3.8	3.3	3.0
300		45.5	17.3	10.8	7.9	6.3	5.3	4.5	4.0	3.6
350		53.1	20.2	12.6	9.3	7.4	6.1	5.3	4.6	4.2
400		60.7	23.1	14.4	10.6	8.4	7.0	6.0	5.3	4.8
50	700	8.8	3.4	2.1	1.5	1.2	1.0	0.9	0.8	0.7
100		17.7	6.7	4.2	3.1	2.4	2.0	1.7	1.5	1.4
150		26.5	10.0	6.3	4.6	3.6	3.0	2.6	2.3	2.0
200		35.3	13.4	8.4	6.1	4.9	4.0	3.5	3.0	2.7
250		44.2	16.8	10.5	7.7	6.1	5.0	4.3	3.8	3.4
300		53.0	20.1	12.6	9.2	7.3	6.1	5.2	4.6	4.1
350		61.8	23.5	14.7	10.7	8.5	7.1	6.1	5.3	4.8
400		70.7	26.9	16.7	12.3	9.7	8.1	6.9	6.1	5.5
50	800	10.1	3.8	2.4	1.7	1.4	1.1	1.0	0.9	0.8
100		20.2	7.7	4.8	3.5	2.8	2.3	2.0	1.7	1.5
150		30.3	11.5	7.1	5.2	4.1	3.4	2.9	2.6	2.3
200		40.4	15.3	9.5	7.0	5.5	4.6	3.9	3.4	3.1
250		50.4	19.1	11.9	8.7	6.9	5.7	4.9	4.3	3.8
300		60.5	22.9	14.3	10.4	8.3	6.9	5.9	5.2	4.6
350		70.6	26.8	16.7	12.2	9.6	8.0	6.9	6.0	5.4
400		80.7	30.6	19.1	13.9	11.0	9.1	7.8	6.9	6.2
50	900	11.3	4.3	2.7	1.9	1.5	1.3	1.1	1.0	0.9
100		22.7	8.6	5.3	3.9	3.1	2.6	2.2	1.9	1.7
150		34.0	12.9	8.0	5.8	4.6	3.8	3.3	2.9	2.6
200		45.4	17.2	10.7	7.8	6.2	5.1	4.4	3.8	3.4
250		56.7	21.5	13.4	9.7	7.7	6.4	5.5	4.8	4.3
300		68.0	25.8	16.0	11.7	9.2	7.7	6.6	5.8	5.1
350		79.4	30.1	17.7	13.6	10.8	8.9	7.7	6.7	6.0
400		90.7	34.4	21.4	15.6	12.3	10.2	8.8	7.7	6.9

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.

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HYATT

ROLLER BEARINGS

QUIET

GRAVITY OF DRY OIL IN OIL-WATER MIXTURES, DEG. A.P.I.

Gravity of "wet" oil deg. A.P.I.	Percent water in mixture														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
40.0	40.4	40.7	41.1	41.5	41.9	42.3	42.8	43.2	43.6	44.1	44.6	45.1	45.6	46.1	46.7
.1	.5	.8	.2	.6	**42.0**	.4	.9	.3	.7	.2	.7	.2	.7	.2	.8
.2	.6	.9	.3	.7	.2	.6	**43.0**	.4	.8	.4	.8	.3	.9	.4	.9
.3	.7	**41.0**	.4	.9	.3	.7	.1	.5	.9	.5	**45.0**	.4	**46.0**	.5	**47.0**
.4	.8	.1	.5	**42.0**	.4	.8	.2	.6	**44.0**	.6	.1	.6	.1	.6	.1
40.5	40.9	41.3	41.6	42.1	42.5	42.9	43.3	43.7	44.2	44.7	45.2	45.7	46.2	46.7	47.2
.6	**41.0**	.3	.7	.2	.6	**43.0**	.4	.9	.3	.9	.3	.8	.3	.8	.3
.7	.1	.4	.8	.3	.7	.1	.6	**44.0**	.5	**45.0**	.5	.9	.4	.9	.5
.8	.1	.5	.9	.4	.8	.2	.7	.1	.6	.1	.6	**46.0**	.6	**47.0**	.7
.9	.2	.6	**42.0**	.5	.9	.3	.8	.2	.7	.2	.7	.1	.7	.2	.8
41.0	41.3	41.7	42.1	42.6	**43.0**	43.4	43.9	44.3	44.8	45.3	45.8	46.3	46.8	47.4	47.9
.1	.5	.8	.2	.7	.2	.5	**44.0**	.5	.9	.5	.9	.4	**47.0**	.5	**48.0**
.2	.6	.9	.4	.8	.3	.6	.2	.6	**45.0**	.6	**46.0**	.5	.1	.7	.2
.3	.7	**42.0**	.5	.9	.4	.8	.3	.7	.1	.7	.1	.6	.2	.8	.4
.4	.8	.1	.6	**43.0**	.5	.9	.4	.8	.2	.8	.2	.8	.3	.9	.5
41.5	41.9	42.3	42.7	43.1	43.6	**44.0**	44.5	44.9	45.4	45.9	46.4	46.9	47.5	**48.0**	48.6
.6	**42.0**	.4	.8	.2	.7	.1	.6	**45.0**	.5	**46.0**	.5	**47.0**	.6	.2	.7
.7	.1	.5	.9	.3	.8	.2	.7	.1	.6	.2	.6	.2	.8	.3	.9
.8	.2	.6	**43.0**	.4	.9	.3	.7	.3	.7	.3	.7	.3	.9	.4	**49.0**
.9	.3	.7	.1	.5	**44.0**	.4	.8	.4	.8	.4	.8	.4	**48.0**	.5	.1
42.0	42.4	42.8	43.2	43.6	44.1	44.5	44.9	45.5	45.9	46.5	46.9	47.5	48.1	48.6	49.2
.1	.5	.9	.3	.7	.2	.6	**45.0**	.6	**46.0**	.6	**47.0**	.6	.2	.7	.3
.2	.6	**43.0**	.4	.8	.3	.7	.2	.7	.2	.8	.2	.8	.4	.9	.5
.3	.7	.1	.5	.9	.4	.8	.3	.9	.3	.9	.3	.9	.5	**49.0**	.6
.4	.8	.2	.6	**44.0**	.5	.9	.4	**46.0**	.4	**47.0**	.4	**48.0**	.6	.2	.7
42.5	42.9	43.3	43.7	44.2	44.6	**45.0**	45.6	46.1	46.5	47.1	47.6	48.1	48.7	49.3	49.9
.6	**43.0**	.4	.8	.3	.8	.2	.7	.2	.6	.2	.7	.3	.8	.4	**50.0**
.7	.1	.5	.9	.4	.9	.3	.8	.3	.7	.3	.8	.4	.9	.5	.2
.8	.2	.6	**44.0**	.5	**45.0**	.4	.9	.4	.8	.4	.9	.5	**49.0**	.7	.3
.9	.3	.7	.1	.6	.1	.5	**46.0**	.5	**47.0**	.5	**48.0**	.6	.1	.8	.4
43.0	43.4	43.8	44.3	44.7	45.2	45.6	46.1	46.6	47.1	47.6	48.2	48.7	49.3	49.9	50.5
.1	.5	.9	.4	.8	.3	.7	.2	.7	.2	.7	.3	.8	.4	**50.0**	.6
.2	.6	**44.0**	.5	.9	.4	.8	.4	.9	.4	.8	.4	**49.0**	.5	.2	.8
.3	.7	.1	.6	**45.0**	.5	.9	.5	**47.0**	.5	**48.0**	.5	.1	.7	.3	.9
.4	.8	.2	.7	.1	.6	**46.0**	.6	.1	.6	.1	.6	.2	.8	.4	**51.0**
43.5	43.9	44.3	44.8	45.2	45.7	46.2	46.7	47.2	47.7	48.2	48.8	49.3	49.9	50.5	51.1
.6	**44.0**	.4	.9	.3	.8	.3	.8	.3	.8	.3	.9	.4	**50.0**	.6	.3
.7	.1	.6	**45.0**	.5	.9	.4	.9	.4	.9	.5	**49.0**	.6	.1	.8	.4
.8	.2	.7	.1	.6	**46.0**	.5	**47.0**	.5	**48.0**	.6	.1	.7	.2	.9	.5
.9	.3	.8	.2	.7	.1	.6	.1	.6	.1	.7	.3	.8	.4	**51.0**	.6
44.0	44.4	44.9	45.3	45.8	46.2	46.7	47.2	47.7	48.3	48.8	49.4	49.9	50.5	51.1	51.8
.1	.5	**45.0**	.4	.9	.3	.8	.3	.9	.4	**49.0**	.5	**50.0**	.7	.2	.9
.2	.6	.1	.5	**46.0**	.5	.9	.4	**48.0**	.5	.1	.7	.1	.8	.4	**52.0**
.3	.7	.2	.6	.1	.6	**47.0**	.5	.1	.6	.2	.8	.3	.9	.5	.1
.4	.8	.3	.7	.2	.7	.1	.6	.2	.7	.3	.9	.5	**51.0**	.6	.3
44.5	44.9	45.4	45.8	46.3	46.8	47.3	47.8	48.3	48.8	49.4	**50.0**	50.6	51.2	51.8	52.4
.6	**45.0**	.5	**46.0**	.4	.9	.4	**48.0**	.4	.9	.5	.2	.7	.4	.9	.5
.7	.1	.6	.1	.5	**47.0**	.5	.1	.6	**49.0**	.7	.3	.8	.5	**52.0**	.7
.8	.2	.7	.2	.6	.1	.6	.3	.7	.2	.8	.4	.9	.6	.2	.8
.9	.3	.8	.3	.7	.2	.7	.5	.8	.3	.9	.5	**51.0**	.7	.3	.9

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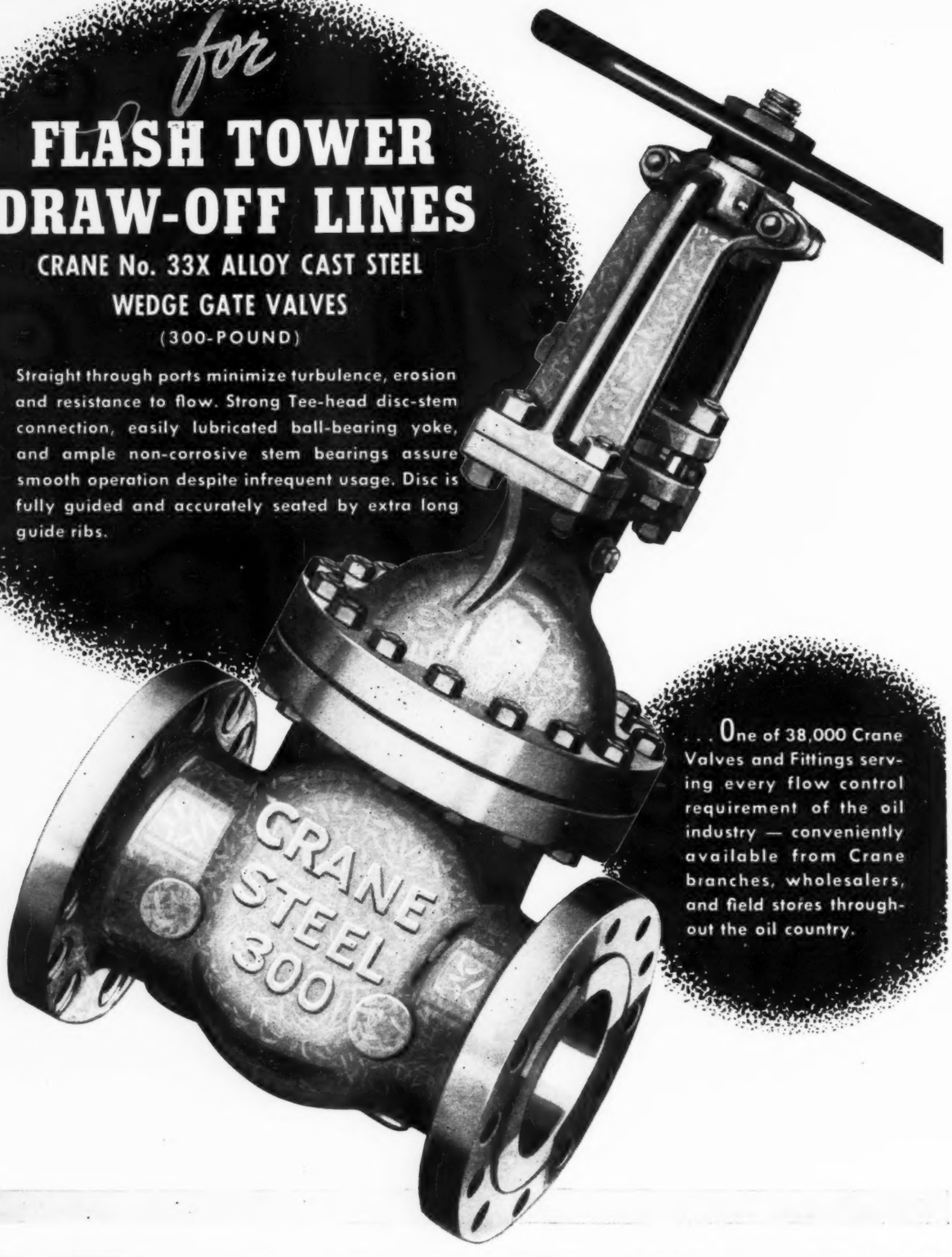
(300-POUND)

Straight through ports minimize turbulence, erosion and resistance to flow. Strong Tee-head disc-stem connection, easily lubricated ball-bearing yoke, and ample non-corrosive stem bearings assure smooth operation despite infrequent usage. Disc is fully guided and accurately seated by extra long guide ribs.



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Static Press.
600-695 lb.

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	600	605	610	615	620	625	630	635	640	645	650	655	660	665	670	675	680	685	690	695
2	35.05	35.21	35.35	35.49	35.63	35.77	35.92	36.06	36.18	36.33	36.47	36.59	36.74	36.88	37.00	37.25	37.27	37.41	37.54	37.68
4	49.58	49.80	50.00	50.20	50.40	50.60	50.80	51.00	51.18	51.38	51.58	51.76	51.96	52.16	52.34	52.34	52.72	52.92	53.10	53.30
6	60.71	60.98	61.23	61.47	61.71	61.96	62.20	62.45	62.67	62.91	63.16	63.38	63.63	63.87	64.09	64.34	64.56	64.80	65.02	65.27
8	70.11	70.42	70.70	70.98	71.27	71.55	71.83	72.11	72.37	72.65	72.93	73.19	73.47	73.75	74.01	74.29	74.55	74.83	75.08	75.37
10	78.39	78.73	79.05	79.37	79.68	80.00	80.31	80.63	80.92	81.23	81.55	81.83	82.15	82.46	82.75	83.07	83.55	83.67	83.95	84.27
12	85.87	86.25	86.60	86.95	87.29	87.64	87.99	88.33	88.64	88.99	89.34	89.65	89.99	90.34	90.65	91.00	91.31	91.66	91.97	92.32
14	92.76	93.18	93.55	93.92	94.30	94.67	95.05	95.42	95.76	96.13	96.51	96.84	97.22	97.59	97.93	98.30	98.64	99.01	99.35	99.72
16	99.16	99.60	100.0	100.4	100.8	101.2	101.6	102.0	102.4	102.8	103.2	103.5	103.9	104.3	104.7	105.1	105.4	105.8	106.2	106.6
18	105.2	105.7	106.1	106.5	106.9	107.3	107.8	108.2	108.6	109.0	109.4	109.8	110.2	110.7	111.0	111.5	111.8	112.3	112.7	113.1
20	110.9	111.4	111.8	112.2	112.7	113.1	113.6	114.0	114.4	114.9	115.3	115.7	116.2	116.6	117.0	117.5	117.9	118.3	118.7	119.2
21	113.6	114.1	114.6	115.0	115.5	115.9	116.4	116.9	117.3	117.7	118.2	118.6	119.1	119.5	119.9	120.4	120.8	121.3	121.7	122.1
22	116.3	116.8	117.3	117.7	118.2	118.7	119.1	119.6	120.0	120.5	121.0	121.4	121.8	122.3	122.7	123.2	123.6	124.1	124.5	125.0
23	118.9	119.4	119.9	120.4	120.9	121.3	121.8	122.3	122.7	123.2	123.7	124.1	124.6	125.1	125.5	126.0	126.4	126.9	127.3	127.8
24	121.4	122.0	122.5	123.0	123.5	123.9	124.4	124.9	125.4	125.9	126.3	126.8	127.3	127.8	128.2	128.7	129.1	129.6	130.1	130.6
25	124.0	124.5	125.0	125.5	126.0	126.5	127.0	127.5	128.0	128.5	129.0	129.4	129.9	130.4	130.9	131.4	131.8	132.3	132.8	133.3
26	126.4	127.0	127.5	128.0	128.5	129.0	129.5	130.0	130.5	131.0	131.5	132.0	132.5	133.0	133.4	134.0	134.4	134.9	135.4	135.9
27	128.8	129.4	129.9	130.4	130.9	131.5	132.0	132.5	133.0	133.5	134.0	134.5	135.0	135.5	136.0	136.5	137.0	137.5	138.0	138.5
28	131.2	131.8	132.3	132.8	133.4	133.9	134.4	134.9	135.4	136.0	136.5	137.0	137.5	138.0	138.5	139.0	139.5	140.0	140.5	141.0
29	133.5	134.1	134.6	135.2	135.7	136.2	136.8	137.3	137.8	138.3	138.9	139.4	139.9	140.4	140.9	141.4	141.9	142.5	143.0	143.5
30	135.8	136.4	136.9	137.5	138.0	138.6	139.1	139.7	140.2	140.7	141.3	141.7	142.3	142.8	143.3	143.8	144.4	144.9	145.0	146.0
31	138.0	138.6	139.2	139.8	140.3	140.9	141.4	142.0	142.5	143.0	143.6	144.1	144.7	145.2	145.7	146.3	146.8	147.3	147.9	148.4
32	140.2	140.9	141.4	142.0	142.6	143.1	143.7	144.3	144.8	145.3	145.9	146.4	147.0	147.5	148.0	148.6	149.1	149.7	150.2	150.8
33	142.4	143.1	143.6	144.2	144.8	145.3	145.9	146.5	147.0	147.6	148.2	148.7	149.3	149.8	150.3	150.9	151.4	152.0	152.5	153.1
34	144.6	145.2	145.8	146.4	146.9	147.5	148.1	148.7	149.2	149.8	150.4	150.9	151.5	152.1	152.6	153.1	153.7	154.3	154.8	155.4
35	146.7	147.3	147.9	148.5	149.1	149.7	150.3	150.9	151.4	152.0	152.6	153.1	153.7	154.3	154.8	155.4	155.9	156.5	157.0	157.7
36	148.7	149.4	150.0	150.6	151.2	151.8	152.4	153.0	153.5	154.1	154.7	155.3	155.9	156.5	157.0	157.7	158.2	158.8	159.3	159.9
37	150.8	151.5	152.1	152.7	153.3	153.9	154.5	155.1	155.7	156.3	156.9	157.4	158.0	158.6	159.2	159.8	160.3	161.0	161.5	162.1
38	152.8	153.5	154.1	154.7	155.3	155.9	156.6	157.2	157.7	158.4	159.0	159.5	160.1	160.8	161.3	161.9	162.5	163.1	163.7	164.3
39	154.8	155.5	156.1	156.7	157.4	158.0	158.6	159.2	159.8	160.4	161.1	161.6	162.2	162.9	163.4	164.0	164.6	165.2	165.8	166.4
40	156.8	157.5	158.1	158.8	159.4	160.0	160.7	161.3	161.9	162.5	163.1	163.7	164.3	165.0	165.5	166.2	166.7	167.4	168.0	168.6
41	158.7	159.4	160.1	160.7	161.4	162.0	162.6	163.3	163.9	164.5	165.1	165.7	166.3	167.0	167.6	168.2	168.8	169.4	170.0	170.6
42	160.7	161.4	162.0	162.7	163.3	164.0	164.6	165.3	165.8	166.5	167.1	167.7	168.4	169.0	169.6	170.2	170.8	171.5	172.1	172.7
43	162.5	163.3	163.9	164.6	165.2	165.9	166.5	167.2	167.6	168.4	169.1	169.7	170.4	171.0	171.6	172.2	172.8	173.5	174.1	174.7
44	164.4	165.2	165.8	166.5	167.2	167.8	168.5	169.1	169.7	170.4	171.1	171.7	172.3	173.0	173.6	174.2	174.8	175.5	176.1	176.8
45	166.3	167.0	167.7	168.4	169.0	169.7	170.4	171.1	171.7	172.3	173.0	173.6	174.3	174.9	175.5	176.2	176.8	177.5	178.1	178.8
46	168.1	168.9	169.6	170.2	170.9	171.6	172.3	172.9	173.6	174.2	174.9	175.5	176.2	176.9	177.5	178.2	178.8	179.5	180.1	180.7
47	170.0	170.7	171.4	172.1	172.8	173.5	174.1	174.8	175.4	176.1	176.8	177.4	178.1	178.8	179.4	180.0	180.7	181.4	182.0	182.7
48	171.7	172.5	173.2	173.9	174.6	175.3	176.0	176.7	177.3	178.0	178.7	179.3	180.0	180.7	181.3	182.0	182.6	183.3	183.9	184.6
49	173.5	174.3	175.0	175.7	177.4	177.1	177.8	178.5	179.1	179.8	180.5	181.2	181.9	182.6	183.2	184.0	184.5	185.2	185.9	186.6
50	175.3	176.1	176.8	177.5	178.2	178.9	179.6	180.3	180.9	181.7	182.4	183.0	183.7	184.4	185.0	185.7	186.4	187.1	187.7	188.4
51	177.0	177.8	178.5	179.2	180.0	180.7	181.4	182.1	182.7	183.5	184.2	184.8	185.5	186.2	186.9	187.6	188.2	189.0	189.6	190.3
52	178.8	179.6	180.3	181.0	181.7	182.4	183.2	183.9	184.5	185.3	186.0	186.6	187.3	188.1	188.7	189.4	190.1	190.8	191.5	192.2
53	180.5	181.3	182.0	182.7	183.5	184.2	184.9	185.6	186.3	187.0	187.8	188.4	189.1	189.9	190.5	191.2	191.9	192.6	193.3	194.0
54	182.2	183.0	183.7	184.4	185.2	185.9	186.6	187.4	188.0	188.8	189.5	190.2	190.9	191.6	192.3	193.0	193.7	194.4	195.1	195.8
55	183.8	184.7	185.4	186.1	186.9	187.6	188.4	189.1	189.8	190.5	191.3	191.9	192.7	193.4	194.1	194.8	195.5	196.2	196.9	197.6
56	185.5	186.3	187.1	187.8	188.6	189.3	190.1	190.8	191.5	192.2	193.0	193.7	194.4	195.2	195.8	196.6	197.3	198.0	198.7	199.4
57	187.2	188.0	188.8	189.5	190.3	191.0	191.8	192.5	193.2	194.0	194.7	195.4	196.1	196.9	197.6	198.3	199.0	199.8	200.5	201.2
58	188.8	189.6	190.4	191.2	191.9	192.7	193.4	194.2	194.9	195.7	196.4	197.1	197.9	198.6	199.3	200.0	200.8	201.5	202.2	203.0
59	190.4	191.3	192.0	192.8	193.6	194.3	195.1	195.9	196.6	197.3	198.1	198.8	199.6	200.3	201.0	201.8	202.5	203.2	203.9	204.7
60	192.0	192.9	193.7	194.4	195.2	196.0	196.7	197.5	198.2	199.0	199.8	200.5	201.2	202.0	202.7	203.5	204.2	205.0	205.7	206.4
61	193.6	194.5	195.3	196.0	196.8	197.6	198.4	199.2	199.9	200.6	201.4	202.1	202.9	203.7	204.4	205.2	205.9	206.7	207.4	208.1
62	195.2	196.1	196.9	197.6	198.4	199.2	200.0	200.8	201.5	202.3	203.1	203.8	204.6	205.4	206.1	206.9	207.6	208.3	209.1	209.8
63	196.8	197.6	198.4	199.2	200.0	200.8	201.6	202.4	203.1	203.9	204.7	205.4	206.2	207.0	207.7	208.4	209.2	210.0	210.7	211.5
64	198.3	199.2	200.0	200.8	201.6	202.4	203.2	204.0	204.7	205.5	206.3	207.0	207.8	208.6	209.4	210.2	210.9	211.7	212.4	213.2
65	199.9	200.7	201.6	202.4	203.2	204.0	204.8	205.6	206.3	207.1	207.9	208.6	209.5	210.3	211.0	211.7	212.5	213.3	214.0	214.9
66	201.4	202.3	203.1	203.9	204.7	205.5	206.3	207.2	207.9	208.7	209.5	210.2	211.1	211.9	212.6	213.4	214.1	215.0	215.7	216.5
67	202.9	203.8	204.6	205.4	206.3	207.1	207.9	208.7	209.5	210.3	211.1	211.8	212.6	213.5	214.2	215.0	215.8	216.6	217.3	218.1
68	204.4	205.3	206.2	207.0	207.8	208.6	209.4	210.3	211.0	211.8	212.7	213.4	214.2	215.1	215.8	216.2	217.4	218.2	218.9	219.8
69	205.9	206.8	207.7	208.5	209.3	210.2	211.0	211.8	212.6	213.4	214.2	215.0	215.8	216.6	217.4	218.2	219.0	219.8	220.6	221.4
70	207.4	208.3	209.2	210.0	210.8	211.7	212.5	213.4	214.1	214.9	215.8	216.5	217.4	218.2	219.0	219.8	220.6	221.4	222.1	223.0
71	208.9	209.8	210.7	211.5	212.3	213.2	214.0	214.9	215.6	216.5	217.3	218.1	218.9	219.8	220.5	221.3	222.1	223.0	223.7	224.6
72	210.3	211.3	212.1	213.0	213.8	214.7	215.5	216.4	217.1	218.0	218.8	219.6	220.4	221.3	222.1	222.9	223.7	224.5	225.3	226.1
73	211.8	212.7	213.6	214.5	215.3	216.2	217.0	217.9	218.6	219.5	220.3	221.1	222.0	222.8	223.6	224.4	225.2	226.1	226.8	227.7
74	213.2	214.2	215.1	215.9	216.8	217.6	218.5	219.4	220.1	221.0	221.8	222.6	223.5	224.3	225.1	225.9	226.7	227.6	228.4	229.2
75	214.7	215.6	216.5	217.4	218.2	219.1	220.0	220.8	221.6	222.5	223.3	224.1	225.0	225.9	226.6	227.4	228.3	229.1	229.9	230.8
76	216.1	217.1	218.0	218.8	219.7	220.6	221.4	222.3	223.1	224.0	224.8	225.6	226.5	227.4	228.2	229.0	229.8	230.7	231.5	232.3
77	217.5	218.5	219.4	220.3	221.1	222.0	222.9	223.8	224.6	225.4	226.3	227.1	228.0	228.5	229.6	230.4	231.3	232.2	233.0	233.9
78	218.9	219.9	220.8	221.7	222.6	223.4	224.3	225.2	226.0	226.9	227.8	228.6	229.5	230.3	231.1	232.0	232.8	233.7	234.5	235.4
79	220.3	221.3	222.2	223.1	224.0	224.9	225.8	226.6	227.4	228.3	229.2	230.0	230.9	231.8	232.6	233.4	234.3	235.2	236.0	236.9
80	221.7	222.7	223.6	224.5	255.4	226.3	227.2	228.1	228.9	229.8	230.7	231.5	232.4	233.3	234.1	235.0	235.8	236.7	237.5	238.4
82	224.5	225.5	226.4	227.3	228.2	229.1	230.0	230.9	231.7	232.6	233.5	234.3	235.2	236.2	237.0	237.8	238.7	239.6	240.4	241.3
84	227.2	228.2	229.1	230.0	231.0	231.9	232.8	233.7	234.5	235.4	236.4	237.2	238.1	239.0	239.8	240.7	241.6	242.5	243.3	244.2
86	229.9	230.9	231.9	232.8	233.7	234.6	235.6	236.5	237.3	238.2	239.2	240.0	240.9	241.9	242.7	243.6	244.5	245.4	246.2	247.2
88	232.6	233.6	234.5	235.5	236.4	237.3	238.3	239.2	240.1	241.0	241.9	242.8	243.7	244.7	245.5	246.4	247.3	248.2	249.1	250.0
90	235.2	236.2	237.2	238.1	239.1	240.0	241.0	241.9	242.8	243.7	244.7	245.5	246.5	247.4	248.3	249.2	250.1	251.0	251.9	252.8
92	237.8	238.8	239.8	240.8	241.7	242.7	243.6	244.6	245.5	246.4	247.4	248.2	249.2	250.2	251.0	251.9	252.8	253.8	254.7	255.6
94	240.3	241.4	242.4	243.8	244.3	245.3	246.3	247.2	248.1	249.1	250.0	250.9	251.9	252.8	253.7	254.7	255.6	256.5	257.4	258.4
96	242.9	244.0	245.0	245.9	246.9	247.9	248.9	249.8	250.7	251.7	252.7	253.6	254.6	255.5	256.4	257.3	258.3	259.3	260.1	261.1
98	245.4	246.5	247.5	248.5	249.5	250.4	251.4	252.4	253.3	254.3	255.3	256.2	257.2	258.2	259.1	260.0	260.9	261.9	262.8	263.8
100	248.0	249.0	250.0	251.0	252.0	253.0	254.0	255.0	255.9	256.9	257.9	258.8	259.8	260.8	261.7	262.7	263.6	264.6	265.5	266.5

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water, respectively.

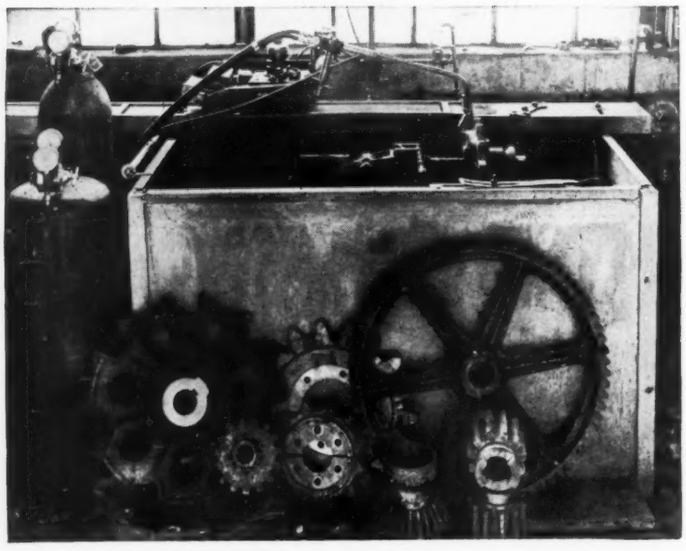
Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.

Table has been condensed to serve field men in approximating meter readings; intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

AIRCO FLAME-HARDENING

. . . makes wearing parts last longer — equipment more serviceable

Close-up of gear tooth being flame-hardened, showing water quench.



A group of flame-hardened parts used in Buckeye equipment.

Vital wearing parts—spur gear teeth, bevel pinions, sprockets, dipper teeth—last many times their normal life span when Airco Flame-Hardened. That's why the Buckeye Traction Ditcher Company, Findlay, Ohio, utilizes this quick, inexpensive Airco process to safeguard wearing parts on their construction equipment—and assure maximum, trouble-free service for the buyer. This process has enabled Buckeye to maintain a stock of hardened parts which can be machined to proper hub bore when needed. » » » This economical Airco method of case hardening steel surfaces is accomplished without materially affecting the physical properties of the core. More ductile metal, highly resistant to shock and strain, without danger of warpage, is assured when parts are Airco Flame-Hardened. » » » The facilities of Airco's Applied Engineering Department are available to help Airco customers solve problems involving surface wear. Write for full details.

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AIRCO *Anything and Everything for* GAS WELDING or CUTTING and ARC WELDING WILSON

Static Press.
700-795 lb.

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	700	705	710	715	720	725	730	735	740	745	750	755	760	765	770	775	780	785	790	795
2	37.81	37.94	38.08	38.21	38.33	38.46	38.59	38.73	38.86	38.98	39.11	39.24	39.37	39.49	39.62	39.75	39.87	39.99	40.12	40.24
4	53.48	53.46	53.86	54.04	54.22	54.40	54.58	54.78	54.96	55.14	55.32	55.50	55.68	55.86	56.04	56.22	56.40	56.56	56.74	56.92
6	65.49	65.71	65.95	66.17	66.39	66.61	66.83	67.08	67.30	67.52	67.74	67.96	68.18	68.40	68.62	68.84	69.06	69.26	69.48	69.70
8	75.62	75.88	76.16	76.41	76.67	76.92	77.18	77.46	77.71	77.97	78.22	78.48	78.73	78.99	79.24	79.50	79.75	79.98	80.23	80.48
10	84.55	84.84	85.15	85.44	85.72	86.01	86.29	86.61	86.89	87.18	87.46	87.75	88.03	88.31	88.60	88.88	89.17	89.42	89.71	89.99
12	92.63	92.94	93.29	93.60	93.91	94.22	94.53	94.88	95.19	95.50	95.81	96.13	96.44	96.75	97.06	97.37	97.68	97.96	98.27	98.59
14	100.1	100.4	100.8	101.1	101.4	101.8	102.1	102.5	102.8	103.2	103.5	103.8	104.2	104.5	104.9	105.2	105.5	105.8	106.2	106.5
16	107.0	107.3	107.7	108.1	108.4	108.8	109.2	109.6	109.9	110.3	110.6	111.0	111.4	111.7	112.1	112.4	112.8	113.1	113.5	113.8
18	113.5	113.8	114.3	114.6	115.0	115.4	115.8	116.2	116.6	117.0	117.4	117.7	118.1	118.5	118.9	119.3	119.7	120.0	120.4	120.8
20	119.6	120.0	120.4	120.8	121.2	121.6	122.0	122.5	122.9	123.3	123.7	124.1	124.5	124.9	125.3	125.7	126.1	126.5	126.9	127.3
21	122.5	123.0	123.4	123.8	124.2	124.7	125.1	125.5	125.9	126.4	126.8	127.2	127.6	128.0	128.4	128.8	129.2	129.6	130.0	130.4
22	125.4	125.8	126.3	126.7	127.1	127.6	128.0	128.5	126.9	129.3	129.7	130.1	130.6	131.0	131.4	131.8	132.3	132.6	133.1	133.5
23	128.2	128.7	129.2	129.6	130.0	130.5	130.9	131.4	131.8	132.2	132.7	133.1	133.5	134.0	134.4	134.8	135.2	135.6	136.1	136.5
24	131.1	131.4	131.9	132.4	132.8	133.3	133.7	134.2	134.6	135.1	135.5	135.9	136.4	136.8	137.3	137.7	138.2	138.5	139.0	139.4
25	133.7	134.2	134.7	135.1	135.6	136.0	136.5	137.0	137.4	137.9	138.3	138.8	139.2	139.7	140.1	140.6	141.0	141.4	141.9	142.3
26	136.3	136.8	137.3	137.8	138.2	138.7	139.2	139.7	140.1	140.6	141.0	141.5	142.0	142.4	142.9	143.3	143.8	144.2	144.7	145.1
27	138.9	139.4	139.9	140.4	140.9	141.3	141.8	142.3	142.8	143.3	143.7	144.2	144.7	145.1	145.6	146.1	146.5	146.9	147.4	147.9
28	141.5	142.0	142.5	143.0	143.5	143.9	144.4	144.9	145.4	145.9	146.4	146.9	147.3	147.8	148.3	148.8	149.2	149.7	150.1	150.6
29	144.0	144.5	145.0	145.5	146.0	146.5	147.0	147.5	148.0	148.5	148.9	149.4	149.9	150.4	150.9	151.4	151.9	152.3	152.8	153.3
30	146.5	146.9	147.5	148.0	148.5	149.0	149.5	150.0	150.5	151.0	151.5	152.0	152.5	153.0	153.5	154.0	154.5	154.9	155.4	155.9
31	148.9	149.4	149.9	150.4	150.9	151.4	152.0	152.5	153.0	153.5	154.0	154.5	155.0	155.5	156.0	156.5	157.0	157.5	158.0	158.5
32	151.3	151.8	152.3	152.9	153.4	153.9	154.4	154.9	155.5	156.0	156.5	157.0	157.5	158.0	158.5	159.0	159.5	160.0	160.5	161.0
33	153.6	154.1	154.7	155.2	155.7	156.3	156.8	157.4	157.9	158.4	158.9	159.4	159.9	160.5	161.0	161.5	162.0	162.5	163.0	163.5
34	155.9	156.4	157.0	157.6	158.1	158.6	159.1	159.7	160.2	160.8	161.3	161.8	162.3	162.9	163.4	163.9	164.4	164.9	165.4	166.0
35	158.2	158.7	159.3	159.9	160.4	160.9	161.4	162.0	162.6	163.1	163.6	164.2	164.7	165.2	165.8	166.3	166.8	167.3	167.8	168.4
36	160.4	161.0	161.6	162.1	162.7	163.2	163.7	164.3	164.9	165.4	166.0	166.5	167.0	167.6	168.1	168.7	169.2	169.7	170.2	170.8
37	162.7	163.2	163.8	164.4	164.9	165.5	166.0	166.6	167.2	167.7	168.3	168.8	169.4	169.9	170.4	171.0	171.5	172.0	172.6	173.1
38	164.8	165.4	166.0	166.6	167.1	167.7	168.2	168.8	169.4	169.9	170.5	171.1	171.6	172.2	172.7	173.3	173.8	174.3	174.9	175.4
39	167.0	167.6	168.2	168.7	169.3	169.9	170.4	171.1	171.6	172.2	172.7	173.3	173.9	174.4	175.0	175.5	176.1	176.6	177.2	177.7
40	169.1	169.7	170.3	170.9	171.5	172.0	172.6	173.2	173.8	174.4	174.9	175.5	176.1	176.7	177.2	177.8	178.4	178.9	179.4	180.0
41	171.2	171.8	172.4	173.0	173.6	174.2	174.7	175.4	176.0	176.5	177.1	177.7	178.3	178.8	179.4	180.0	180.6	181.1	181.7	182.2
42	173.3	173.9	174.5	175.1	175.7	176.3	176.9	177.5	178.1	178.7	179.3	179.8	180.4	181.0	181.6	182.2	182.8	183.3	183.9	184.4
43	175.3	175.9	176.6	177.2	177.8	178.4	178.9	179.6	180.2	180.8	181.4	182.0	182.5	183.1	183.7	184.3	184.9	185.4	186.0	186.6
44	177.4	178.0	178.6	179.2	179.8	180.4	181.0	181.7	182.3	182.9	183.5	184.1	184.7	185.3	185.9	186.5	187.1	187.6	188.2	188.8
45	179.4	180.0	180.6	181.3	181.9	182.5	183.1	183.7	184.3	184.9	185.5	186.1	186.8	187.4	188.0	188.6	189.2	189.7	190.3	190.9
46	181.4	182.0	182.6	183.2	183.9	184.5	185.1	185.8	186.4	187.0	187.6	188.2	188.8	189.4	190.0	190.6	191.1	191.8	192.4	193.0
47	183.3	183.9	184.6	185.2	185.9	186.5	187.1	187.8	188.4	189.0	189.6	190.3	190.9	191.5	192.1	192.7	193.3	193.9	194.5	195.1
48	185.3	185.9	186.6	187.2	187.8	188.4	189.1	189.8	190.4	191.0	191.6	192.3	192.9	193.5	194.1	194.7	195.4	195.9	196.5	197.2
49	187.2	187.8	188.5	189.1	189.8	190.4	191.0	191.7	192.3	193.0	193.6	194.3	194.9	195.5	196.1	196.8	197.4	198.0	198.6	199.2
50	189.1	189.7	190.4	191.1	191.7	192.3	193.0	193.7	194.3	194.9	195.6	196.2	196.9	197.5	198.1	198.8	199.4	200.0	200.6	201.2
51	191.0	191.6	192.3	192.9	193.6	194.2	194.9	195.6	196.2	196.9	197.5	198.1	198.8	199.4	200.1	200.7	201.4	201.9	202.6	203.2
52	192.8	193.5	194.2	194.8	195.5	196.1	196.8	197.5	198.2	198.8	199.5	200.1	200.8	201.4	202.1	202.7	203.4	203.9	204.6	205.2
53	194.7	195.3	196.1	196.7	197.4	198.0	198.7	199.4	200.1	200.7	201.4	202.0	202.7	203.3	204.0	204.6	205.3	205.9	206.5	207.2
54	196.5	197.1	197.9	198.5	199.2	199.9	200.5	201.3	201.9	202.6	203.2	203.9	204.6	205.2	205.9	206.6	207.2	207.8	208.5	209.1
55	198.3	199.0	199.7	200.4	201.0	201.7	202.4	203.1	203.8	204.5	205.1	205.8	206.5	207.1	207.8	208.5	209.1	209.7	210.4	211.0
56	200.1	200.8	201.5	202.2	202.9	203.5	204.2	205.0	205.6	206.3	207.0	207.7	208.3	209.0	209.7	210.3	211.0	211.6	212.3	213.0
57	201.9	202.6	203.3	204.0	204.7	205.4	206.0	206.8	207.5	208.2	208.8	209.5	210.2	210.9	211.6	212.2	212.9	213.5	214.2	214.9
58	203.7	204.3	205.1	205.8	206.5	207.2	207.8	208.6	209.3	210.0	210.7	211.3	212.0	212.7	213.4	214.1	214.8	215.4	216.1	216.8
59	205.3	206.1	206.8	207.5	208.2	208.9	209.6	210.4	211.1	211.8	212.5	213.1	213.8	214.5	215.2	215.9	216.6	217.2	217.9	218.6
60	207.1	207.8	208.6	209.3	210.0	210.7	211.4	212.2	212.9	213.6	214.3	215.0	215.6	216.3	217.0	217.7	218.4	219.1	219.8	220.5
61	208.8	209.5	210.3	211.0	211.7	212.4	213.1	213.9	214.6	215.3	216.0	216.7	217.4	218.1	218.8	219.5	220.2	220.9	221.6	222.3
62	210.6	211.3	212.0	212.8	213.5	214.2	214.9	215.7	216.4	217.1	217.8	218.5	219.2	219.9	220.6	221.3	222.0	222.7	223.4	224.1
63	212.2	212.9	213.7	214.5	215.2	215.9	216.6	217.4	218.1	218.8	219.5	220.3	221.0	221.7	222.4	223.1	223.8	224.5	225.0	225.9
64	213.9	214.6	215.4	216.2	216.9	217.6	218.3	219.1	219.8	220.6	221.3	222.0	222.7	223.4	224.2	224.9	225.6	226.2	227.0	227.7
65	215.6	216.3	217.1	217.8	218.6	219.3	220.0	220.8	221.5	222.3	223.0	223.7	224.4	225.2	225.9	226.6	227.3	228.0	228.7	229.4
66	217.2	218.0	218.8	219.5	220.2	221.0	221.7	222.5	223.2	224.0	224.7	225.4	226.2	226.9	227.6	228.4	229.1	229.7	230.5	231.2
67	218.9	219.6	220.4	221.2	221.9	222.6	223.4	224.2	224.9	225.7	226.4	227.1	227.9	228.6	229.3	230.1	230.8	231.5	232.2	232.9
68	220.5	221.2	222.1	222.8	223.5	224.3	225.0	225.9	226.6	227.3	228.1	228.8	229.6	230.3	231.1	231.8	232.5	233.2	233.9	234.7
69	222.1	222.9	223.7	224.5	225.2	226.0	226.7	227.5	228.3	229.0	229.8	230.5	231.3	232.0	232.8	233.5	234.3	234.9	235.7	236.4
70	223.7	224.5	225.3	226.1	226.8	227.6	228.3	229.2	229.9	230.7	231.4	232.2	232.9	233.7	234.4	235.2	235.9	236.6	237.4	238.1
71	225.3	226.1	226.9	227.7	228.4	229.2	229.9	230.8	231.5	232.3	233.1	233.8	234.6	235.3	236.1	236.9	237.6	238.3	239.0	239.8
72	226.9	227.7	228.5	229.2	230.0	230.8	231.6	232.4	233.2	233.9	234.7	235.5	236.2	237.0	237.7	238.5	239.3	240.0	240.7	241.5
73	228.5	229.2	230.1	230.9	231.6	232.4	233.2	234.0	234.8	235.6	236.3	237.1	237.9	238.6	239.4	240.2	240.9	241.6	242.4	243.2
74	230.0	230.8	231.7	232.4	233.2	234.0	234.7	235.6	236.4	237.2	237.9	238.7	239.5	240.3	241.0	241.8	242.6	243.3	244.0	244.8
75	231.6	232.3	233.2	234.0	234.7	235.6	236.3	237.2	238.0	238.8	239.5	240.3	241.1	241.9	242.7	243.4	244.2	244.9	245.7	246.5
76	233.1	233.9	234.8	235.6	236.3	237.1	237.9	238.8	239.6	240.4	241.1	241.9	242.7	243.5	244.3	245.1	245.8	246.5	247.3	248.1
77	234.6	235.4	236.3	237.1	237.9	238.7	239.5	240.3	241.1	241.9	242.7	243.5	244.3	245.1	245.9	246.7	247.5	248.2	248.9	249.7
78	236.2	237.0	237.8	238.6	239.4	240.2	241.0	241.9	242.7	243.5	244.3	245.1	245.9	246.7	247.5	248.3	249.1	249.8	250.6	251.4
79	237.7	238.5	239.4	240.2	241.0	241.8	242.6	243.4	244.2	245.0	245.8	246.6	247.4	248.2	249.0	249.8	250.6	251.4	252.2	253.0
80	239.2	240.0	240.9	241.7	242.5	243.3	244.1	245.0	245.8	246.6	247.4	248.2	249.0	249.8	250.6	251.4	252.2	252.9	253.7	254.5
82	242.1	242.9	243.9	244.7	245.5	246.3	247.1	248.0	248.8	249.6	250.5	251.3	252.1	252.9	253.7	254.5	255.4	256.1	256.9	257.7
84	245.1	245.9	246.8	247.6	248.5	249.3	250.1	251.0	251.9	252.7	253.5	254.3	255.2	256.0	256.8	257.6	258.5	259.2	260.0	260.8
86	248.0	248.8	249.7	250.6	251.4	252.3	253.1	254.0	254.8	255.7	256.5	257.4	258.2	259.0	259.9	260.7	261.5	262.3	263.1	263.9
88	250.8	251.7	252.6	253.5	254.3	255.2	256.0	256.9	257.8	258.6	259.5	260.3	261.2	262.0	262.9	263.7	264.5	265.3	266.1	267.0
90	253.7	254.5	255.5	256.3	257.2	258.0	258.9	259.8	260.7	261.6	262.4	263.3	264.1	265.0	265.8	266.7	267.5	268.3	269.1	270.0
92	256.5	257.4	258.3	259.2	260.0	260.9	261.8	262.7	263.6	264.5	265.3	266.2	267.0	267.9	268.8	269.6	270.5	271.3	272.1	273.0
94	259.2	260.1	261.1	262.0	262.8	263.7	264.6	265.5	266.4	267.3	268.2	269.0	269.9	270.8	271.7	272.5	273.4	274.2	275.0	275.9
96	262.0	262.9	263.9	264.7	265.6	266.5	267.4	268.4	269.2	270.1	271.0	271.9	272.8	273.7	274.5	275.4	276.3	277.1	278.0	278.9
98	264.7	265.6	266.6	267.5	268.4	269.3	270.1	271.1	272.0	272.9	273.8	274.7	275.6	276.5	277.4	278.3	279.2	279.9	280.8	281.7
100	267.4	268.3	269.3	270.2	271.1	272.0	272.9	273.9	274.8	275.7	276.6	277.5	278.4	279.3	280.2	281.1	282.0	282.8	283.7	284.6

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water, respectively.

Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.

Table has been condensed to serve field men in approximating meter readings; intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

We Invite Comparison

and then . . .

You be the Judge

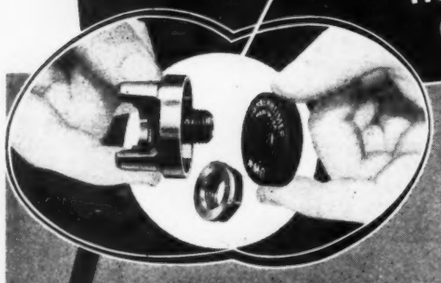
Gland with hexagon head for wrench hold
Stem material is a new Lunkenheimer development providing exceptional resistance to stem-thread wear
Disc holder slip-on type. Perfectly guided. Extremely close tolerances prevent "cocking"
Non-heat handwheel. Operator's hand does not contact end of stem, which may be hot
Repackable under pressure. Repacking seat above stem thread
Screw-over bonnet provides great strength
Non-metallic disc easily renewed

FIG. 123 "N-M-D" GLOBE VALVE

Direct comparison is a sound basis on which to buy. We believe that the "N-M-D" Valve is the finest valve in its class. We want you to believe it. The most convincing way we know to prove it is to suggest a direct comparison with any other make of valve designed for the same services.

Tell your Lunkenheimer distributor you want to see a Fig. 123 "N-M-D" VALVE. First, examine it externally — *critically*. Note the fine casting—get its feel of sturdiness. Then take it apart . . . compare it point by point — from every angle of service-giving design and construction. We'll rest the case in your hands.

"N-M-D" Valves are made in Globe, Angle, Check and Quick Operating Patterns — with various types of discs for steam, hot water, cold water, air, gas, gasoline, oil, butane and propane. Available from Lunkenheimer distributors in all industrial centers.



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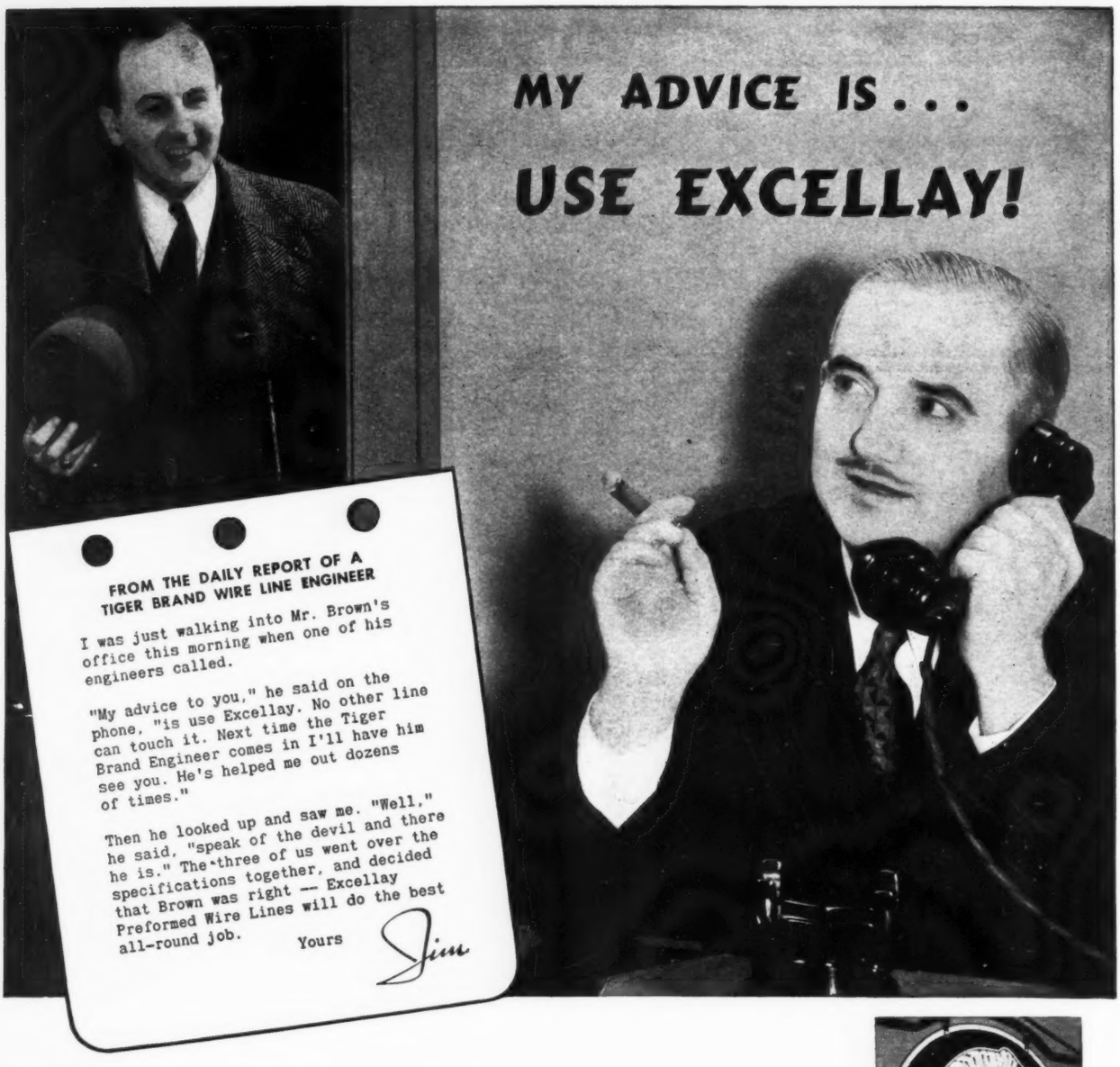
Send for copy of Catalog No. 78. We will include our handy "Guide", for easy selection of valves, boiler mountings and lubricating devices.

VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 1¼-IN. AND 4-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	300	2.5	1.0	0.7	0.5	0.4	0.3	0.3	0.2	0.2
100		5.0	1.9	1.5	0.9	0.7	0.6	0.5	0.5	0.4
150		7.5	2.9	2.2	1.4	1.1	0.9	0.8	0.7	0.7
200		10.0	3.9	2.9	1.8	1.5	1.2	1.1	1.0	0.9
250		12.6	4.9	3.7	2.3	1.8	1.6	1.4	1.2	1.1
300		15.1	5.8	4.4	2.7	2.2	1.9	1.6	1.4	1.3
350		17.6	6.8	5.1	3.2	2.6	2.2	1.9	1.7	1.5
400		20.1	7.8	5.9	3.7	2.9	2.5	2.2	1.9	1.7
50	400	3.3	1.3	0.8	0.6	0.5	0.4	0.3	0.3	0.3
100		6.7	2.6	1.6	1.2	0.9	0.8	0.7	0.6	0.6
150		10.0	3.8	2.4	1.8	1.4	1.2	1.0	0.9	0.8
200		13.3	5.1	3.2	2.4	1.9	1.6	1.4	1.2	1.1
250		16.7	6.4	4.0	3.0	2.4	2.0	1.7	1.5	1.4
300		20.0	7.7	4.8	3.6	2.8	2.4	2.1	1.8	1.7
350		23.3	9.0	5.6	4.2	3.3	2.8	2.4	2.1	1.9
400		26.7	10.2	6.4	4.8	3.8	3.2	2.8	2.4	2.2
50	500	4.2	1.6	1.0	0.7	0.6	0.5	0.4	0.4	0.3
100		8.3	3.2	2.0	1.5	1.2	1.0	0.8	0.7	0.7
150		12.5	4.8	2.9	2.2	1.7	1.5	1.3	1.1	1.0
200		16.6	6.3	4.0	2.9	2.3	1.9	1.7	1.5	1.3
250		20.8	7.9	5.0	3.7	2.9	2.4	2.1	1.9	1.7
300		24.9	9.5	6.0	4.4	3.5	2.9	2.5	2.2	2.0
350		29.1	11.1	7.0	5.1	4.1	3.4	2.9	2.6	2.3
400		33.2	12.7	8.0	5.8	4.7	3.9	3.4	3.0	2.7
50	600	5.0	1.9	1.2	0.9	0.7	0.6	0.5	0.4	0.4
100		10.0	3.8	2.4	1.7	1.4	1.1	1.0	0.9	0.8
150		14.9	5.7	3.6	2.6	2.1	1.7	1.5	1.3	1.2
200		19.9	7.6	4.7	3.5	2.8	2.3	2.0	1.7	1.6
250		24.9	9.5	5.9	4.3	3.4	2.9	2.5	2.2	2.0
300		29.9	11.4	7.1	5.2	4.1	3.4	3.0	2.6	2.3
350		34.8	13.3	8.3	6.1	4.8	4.0	3.5	3.0	2.7
400		39.8	15.2	9.5	6.9	5.5	4.6	4.0	3.5	3.1
50	700	5.8	2.2	1.4	1.0	0.8	0.7	0.6	0.5	0.5
100		11.6	4.4	2.7	2.0	1.6	1.3	1.1	1.0	0.9
150		17.4	6.6	4.1	3.0	2.4	2.0	1.7	1.5	1.3
200		23.2	8.8	5.5	4.0	3.2	2.6	2.3	2.0	1.8
250		29.0	11.0	6.9	5.0	4.0	3.3	2.8	2.5	2.2
300		34.8	13.2	8.2	6.0	4.8	4.0	3.4	3.0	2.7
350		40.6	15.4	9.6	7.0	5.6	4.6	4.0	3.5	3.1
400		46.4	17.6	11.0	8.0	6.4	5.3	4.6	4.0	3.6
50	800	6.6	2.5	1.6	1.1	0.9	0.8	0.6	0.6	0.5
100		13.2	5.0	3.1	2.3	1.8	1.5	1.3	1.1	1.0
150		19.9	7.5	4.7	3.4	2.7	2.3	1.9	1.7	1.5
200		26.5	10.0	6.3	4.6	3.6	3.0	2.6	2.3	2.0
250		33.1	12.6	7.8	5.7	4.5	3.8	3.2	2.8	2.5
300		39.7	15.1	9.4	6.9	5.4	4.5	3.9	3.4	3.0
350		46.3	17.6	10.9	8.0	6.3	5.3	4.5	4.0	3.5
400		53.0	20.1	12.5	9.1	7.2	6.0	5.2	4.5	4.0
50	900	7.4	2.8	1.8	1.3	1.0	0.8	0.7	0.6	0.6
100		14.9	5.6	3.5	2.6	2.0	1.7	1.4	1.3	1.1
150		22.3	8.5	5.3	3.8	3.0	2.5	2.2	1.9	1.7
200		29.8	11.3	7.0	5.1	4.0	3.4	2.9	2.5	2.2
250		37.2	14.1	8.8	6.4	5.1	4.2	3.6	3.2	2.8
300		44.7	16.9	10.5	7.7	6.1	5.0	4.3	3.8	3.4
350		52.1	19.7	12.3	9.0	7.1	5.9	5.0	4.4	3.9
400		60.0	22.7	14.0	10.2	8.1	6.7	6.0	5.0	4.5

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. In calculating the number of atmospheres.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USE EXCELLAY!
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I was just walking into Mr. Brown's office this morning when one of his engineers called.
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Then he looked up and saw me. "Well," he said, "speak of the devil and there he is." The three of us went over the specifications together, and decided that Brown was right — Excellay Preformed Wire Lines will do the best all-round job.
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Jim

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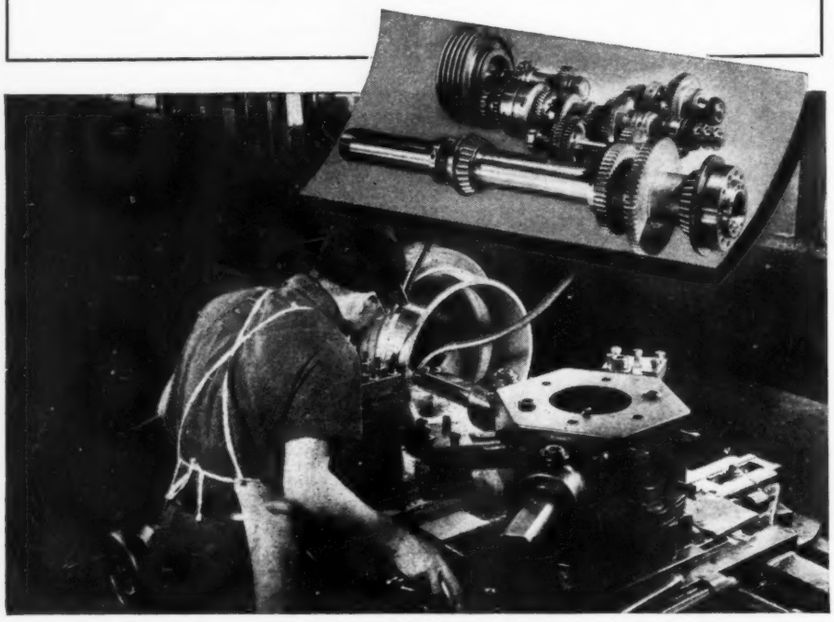
UNITED STATES STEEL

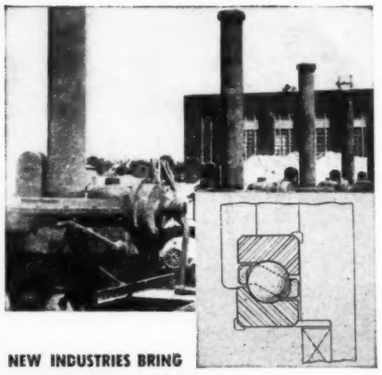
GRAVITY OF DRY OIL IN OIL-WATER MIXTURES, DEG. A.P.I.

Gravity of "wet" oil deg. A.P.I.	Percent water in mixture														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
25.0	28.2	28.5	28.7	**29.0**	29.3	29.5	29.8	30.1	30.4	30.7	31.1	31.4	31.7	32.1	32.4
.1	.3	.6	.8	.1	.4	.6	.9	.2	.5	.8	.2	.5	.8	.2	.5
.2	.4	.7	.9	.2	.5	.7	**30.0**	.3	.6	**31.0**	.3	.7	**32.0**	.4	.7
.3	.5	.8	**29.0**	.3	.6	.9	.2	.5	.8	.1	.5	.9	.1	.5	.8
.4	.7	.9	.2	.5	.8	**30.0**	.3	.6	.9	.3	.6	**32.0**	.3	.7	**33.0**
25.5	28.8	29.1	29.3	29.6	29.9	30.2	30.4	30.8	31.1	31.4	31.8	32.1	32.4	32.8	33.2
.6	.9	.2	.4	.7	**30.0**	.3	.6	.9	.2	.6	.9	.3	.6	**33.0**	.3
.7	29.1	.3	.6	.9	.2	.4	.7	**31.0**	.3	.7	**32.0**	.4	.7	.1	.5
.8	.2	.4	.7	**30.0**	.3	.6	.9	.2	.5	.9	.2	.6	.9	.3	.6
.9	.3	.5	.8	.1	.4	.7	**31.0**	.3	.6	**32.0**	.3	.7	**33.0**	.4	.8
26.0	29.5	29.7	**30.0**	30.3	30.6	30.9	31.2	31.5	31.8	32.2	32.5	32.9	33.2	33.6	**34.0**
.1	.6	.8	.1	.4	.7	**31.0**	.3	.6	.9	.3	.6	33.1	.3	.7	.1
.2	.7	.9	.2	.5	.8	.1	.4	.7	32.1	.4	.8	.2	.5	.9	.3
.3	.8	**30.0**	.3	.6	.9	.2	.6	.9	.3	.6	.9	.3	.6	**34.0**	.4
.4	.9	.2	.5	.8	31.1	.4	.7	**32.0**	.4	.9	33.1	.4	.7	.2	.6
26.5	30.1	30.3	30.6	30.9	31.2	31.5	31.9	32.2	32.5	32.9	33.2	33.6	**34.0**	34.4	34.8
.6	.2	.4	.7	**31.0**	.3	.6	**32.0**	.3	.7	**33.0**	.4	.8	.1	.5	.9
.7	.3	.6	.9	.2	.5	.8	.1	.4	.8	.1	.5	.9	.3	.7	35.1
.8	.4	.7	**31.0**	.3	.6	.9	.3	.6	**33.0**	.3	.7	34.1	.4	.8	.2
.9	.5	.8	.1	.4	.7	**32.0**	.4	.7	.1	.4	.8	.2	.6	**35.0**	.4
27.0	30.7	**31.0**	31.3	31.6	31.9	32.2	32.6	32.9	33.3	33.6	**34.0**	34.4	34.8	35.2	35.6
.1	.8	.1	.4	.7	**32.0**	.3	.7	**33.0**	.4	.7	.1	.5	.9	.3	.7
.2	.9	.2	.5	.8	.1	.4	.8	.1	.5	.9	.3	.7	35.1	.5	.9
.3	**31.0**	.3	.6	.9	.2	.6	.9	.3	.7	**34.0**	.4	.8	.2	.6	**36.0**
.4	.2	.5	.8	32.1	.4	.7	33.1	.4	.8	.2	.6	**35.0**	.4	.8	.2
27.5	31.3	31.6	31.9	32.2	32.5	32.9	33.2	33.6	**34.0**	34.3	34.7	35.1	35.5	35.9	36.4
.6	.4	.7	**32.0**	.3	.6	**33.0**	.3	.7	.1	.5	.9	.3	.7	36.1	.5
.7	.6	.9	.2	.5	.8	.1	.5	.8	.2	.6	**35.0**	.4	.8	.2	.7
.8	.7	**32.0**	.3	.6	.9	.3	.6	**34.0**	.4	.8	.2	.6	**36.0**	.4	.8
.9	.8	.1	.4	.7	**33.0**	.4	.7	.1	.5	.9	.3	.7	.1	.5	**37.0**
28.0	**32.0**	32.3	32.6	32.9	33.2	33.5	33.9	34.3	34.7	35.1	35.5	35.9	36.3	36.7	37.2
.1	.1	.4	.7	**33.0**	.3	.6	**34.0**	.4	.8	.2	.6	**36.0**	.4	.8	.3
.2	.2	.5	.8	.1	.4	.7	.1	.5	.9	.3	.7	.1	.5	**37.0**	.5
.3	.3	.7	.9	.3	.7	.9	.3	.6	**35.0**	.4	.8	.2	.6	.1	.6
.4	.4	.8	33.1	.4	.8	34.1	.4	.7	.1	.5	.9	.3	.7	.2	.7
28.5	32.6	32.9	33.2	33.6	33.9	34.3	34.6	**35.0**	35.4	35.8	36.2	36.6	37.1	37.5	**38.0**
.6	.7	**33.0**	.3	.7	34.1	.4	.7	.2	.5	.9	.4	.7	.2	.6	.1
.7	.8	.1	.4	.8	.2	.5	.8	.3	.6	**36.0**	.5	.9	.3	.7	.3
.8	.9	.2	.5	.9	.3	.7	.9	.5	.7	.2	.6	37.1	.5	.9	.5
.9	**33.0**	.3	.7	**34.0**	.4	.8	**35.1**	.7	.9	.4	.8	.2	.7	38.1	.7
29.0	33.2	33.5	33.9	34.2	34.6	34.9	35.3	35.7	36.1	36.5	**37.0**	37.4	37.8	38.3	38.8
.1	.3	.6	**34.0**	.3	.7	**35.0**	.4	.8	.2	.6	.1	.5	**38.0**	.5	**39.0**
.2	.4	.7	.1	.4	.8	.1	.5	.9	.3	.8	.2	.7	.2	.7	.2
.3	.5	.8	.2	.5	.9	.3	.7	36.1	.5	.9	.4	.9	.4	.9	.4
.4	.7	**34.0**	.3	.7	35.1	.4	.8	.2	.6	37.1	.5	38.1	.6	39.1	.6
29.5	33.8	34.2	34.5	34.9	35.2	35.6	**36.0**	36.4	36.8	37.2	37.7	38.3	38.8	39.3	39.8
.6	.9	.3	.6	**35.0**	.3	.7	.1	.5	.9	.4	.8	.4	**39.0**	.5	**40.0**
.7	34.1	.4	.8	.1	.5	.8	.2	.6	**37.0**	.5	.9	.5	.2	.7	.2
.8	.2	.5	.9	.2	.6	.9	.4	.8	.2	.7	**38.0**	.7	.4	.9	.4
.9	.3	.6	**35.0**	.3	.7	36.1	.5	.9	.3	.8	.1	.8	.6	40.1	.6

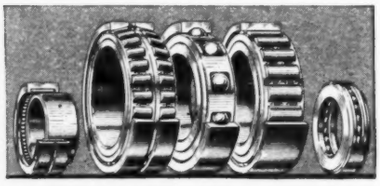
In the News
WITH BANTAM BEARINGS



FAST, ACCURATE PRODUCTION, always essential in machine tools, is more important than ever today. Turret lathes built by Gisholt Machine Company are designed throughout to meet these requirements—and Gisholt employs Bantam Ultra-Precision Tapered Roller Bearings on the spindle of many of its High Production Lathes to maintain the high degree of accuracy necessary in turret lathes. This is an outstanding example of Bantam service to machine tool builders and users.

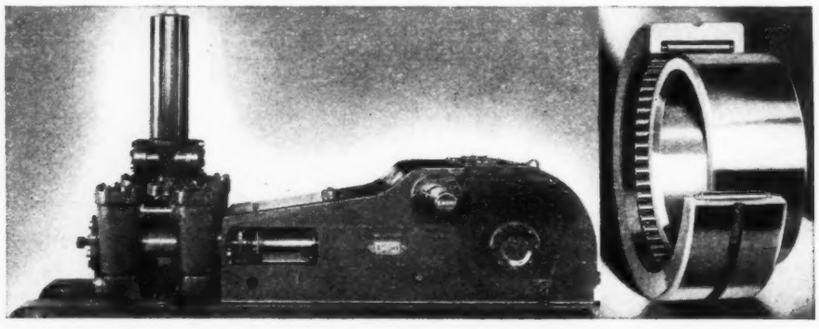


NEW INDUSTRIES BRING NEW PROBLEMS, and Bantam engineers are contributing their skill to the field of sewage treatment. For sluice gates like those shown here, built by The Filer & Stowell Co., Bantam designed special angular contact bearings that take thrust load from both directions, and radial loads also.



EVERY MAJOR TYPE OF ANTI-FRICTION BEARING is included in Bantam's line—straight roller, tapered roller, needle, and ball. Bantam engineers, with their broad background of experience in bearing design and application, can recommend the type that best suits *your* needs—or can design special bearings to meet special conditions. If you have difficult bearing problems, TURN TO BANTAM.

THIS GIANT ROLLER THRUST BEARING, 47½" O.D. by 5" thick, incorporates a split race engineered by Bantam to facilitate accurate positioning in assembly. Bearing was used by S. Morgan Smith Company to support a load of 456,000 pounds in assembling turbine equipment at Bonneville Dam—a typical instance of Bantam's skill in designing special bearings to meet unusual requirements.



LIGHT WEIGHT AND HIGH EFFICIENCY are outstanding advantages of the slush pumps built by Emsco Derrick & Equipment Company. Bantam Quill Bearings, used on the crosshead, contribute to weight reductions through their compact design—to increased efficiency through their low coefficient of friction and little need of service attention, resulting in savings in operating costs. For further information on this unusual bearing, write for Bulletin No. P-104.

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 1¼-IN. AND 3½-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	300	3.5	1.3	0.9	0.6	0.5	0.4	0.4	0.3	0.3
100		7.0	2.7	1.7	1.3	1.0	0.9	0.7	0.7	0.6
150		10.4	4.0	2.6	1.9	1.5	1.2	1.1	1.0	0.9
200		13.9	5.4	3.4	2.5	2.0	1.7	1.5	1.3	1.2
250		17.4	6.7	4.3	3.2	2.6	2.1	1.9	1.7	1.5
300		20.9	8.1	5.1	3.8	3.0	2.6	2.2	2.0	1.8
350		24.3	9.4	6.0	4.4	3.6	3.0	2.6	2.3	2.1
400		27.8	10.7	6.8	5.1	4.1	3.4	3.0	2.7	2.4
50	400	4.6	1.8	1.1	0.8	0.7	0.6	0.5	0.4	0.4
100		9.2	3.5	2.2	1.6	1.3	1.1	1.0	0.8	0.8
150		13.8	5.3	3.3	2.5	2.0	1.7	1.4	1.3	1.1
200		18.5	7.1	4.5	3.3	2.6	2.2	1.9	1.7	1.5
250		23.1	8.9	5.6	4.1	3.3	2.8	2.4	2.1	1.9
300		27.7	10.6	6.7	4.9	3.9	3.3	2.9	2.5	2.3
350		32.3	12.4	7.8	5.8	4.6	3.9	3.3	3.0	2.7
400		36.9	14.2	8.9	6.6	5.3	4.4	3.8	3.4	3.1
50	500	5.8	2.2	1.4	1.0	0.8	0.7	0.6	0.5	0.5
100		11.5	4.4	2.8	2.0	1.6	1.3	1.2	1.0	0.9
150		17.3	6.6	4.1	3.0	2.4	2.0	1.7	1.5	1.4
200		23.0	8.8	5.5	4.0	3.2	2.7	2.3	2.1	1.8
250		28.8	11.0	6.9	5.1	4.0	3.4	2.9	2.6	2.3
300		34.5	13.2	8.3	6.1	4.8	4.0	3.5	3.1	2.8
350		40.3	15.4	9.6	7.1	5.6	4.7	4.1	3.6	3.2
400		46.0	17.6	11.0	8.1	6.4	5.4	4.6	4.1	3.7
50	600	6.9	2.6	1.6	1.2	1.0	0.8	0.7	0.6	0.5
100		13.8	5.2	3.3	2.4	1.9	1.6	1.4	1.2	1.1
150		20.7	7.9	4.9	3.6	2.9	2.4	2.1	1.8	1.6
200		27.6	10.5	6.6	4.8	3.8	3.2	2.7	2.4	2.2
250		34.4	13.1	8.2	5.4	4.8	4.0	3.4	3.0	2.7
300		41.3	15.7	9.8	6.0	5.7	4.8	4.1	3.6	3.2
350		48.2	18.4	11.5	7.2	6.7	5.6	4.8	4.2	3.8
400		55.2	21.0	13.1	8.4	7.6	6.4	5.5	4.8	4.3
50	700	8.0	3.1	1.9	1.4	1.1	0.9	0.9	0.7	0.6
100		16.1	6.1	3.8	2.8	2.2	1.8	1.8	1.4	1.2
150		24.1	9.2	5.7	4.2	3.3	2.8	2.7	2.1	1.9
200		32.1	12.2	7.6	5.6	4.4	3.7	3.6	2.8	2.5
250		40.1	15.3	9.5	7.0	5.5	4.6	4.5	3.5	3.1
300		48.2	18.3	11.4	8.3	6.6	5.5	5.3	4.2	3.7
350		56.2	21.4	13.3	9.7	7.7	6.4	6.2	4.8	4.3
400		64.2	24.4	15.2	11.1	8.8	7.3	7.1	5.5	5.0
50	800	9.2	3.5	2.2	1.6	1.3	1.0	0.9	0.8	0.7
100		18.3	7.0	4.3	3.2	2.5	2.1	1.8	1.6	1.4
150		27.5	10.4	6.5	4.7	3.8	3.1	2.7	2.3	2.1
200		36.7	13.9	8.7	6.3	5.0	4.2	3.6	3.1	2.8
250		45.8	17.4	10.8	7.9	6.3	5.2	4.5	3.9	3.5
300		55.0	20.9	13.0	9.5	7.5	6.2	5.3	4.7	4.2
350		64.2	24.3	15.1	11.1	8.8	7.3	6.2	5.5	4.9
400		73.3	27.8	17.3	12.7	10.0	8.3	7.1	6.3	5.6
50	900	10.3	3.9	2.4	1.8	1.4	1.2	1.0	0.9	0.8
100		20.6	7.8	4.9	3.5	2.8	2.3	2.0	1.7	1.6
150		30.9	11.7	7.3	5.3	4.2	3.5	3.0	2.6	2.3
200		41.2	15.6	9.7	7.1	5.6	4.6	4.1	3.5	3.1
250		51.5	19.5	12.1	8.9	7.0	5.8	5.1	4.4	3.9
300		61.8	23.5	14.6	10.6	8.4	7.0	6.1	5.2	4.7
350		72.1	27.3	17.0	12.4	9.8	8.1	7.1	6.1	5.4
400		82.4	31.2	19.4	14.2	11.2	9.3	8.1	7.0	6.2

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.

"WE CROSSED OUR FINGERS FOR MORE THAN 3 HOURS

. . . but that UNAFLO cement came out just as pretty as it went in!"

"EVERYTHING was O.K.," reports a superintendent of a deep outpost well in coastal Louisiana, "until we attempted to squeeze just above 9,000 feet. Bottom hole pressure was 4,400 pounds, and temperature above 200 degrees. We squeezed with 500 sacks of Unaflo and kept pumping Unaflo into the formation until the pump pressure reached 5,000 pounds. There were 235 sacks of Unaflo remaining in the tubing which had to be reversed out.

"When we reversed, all hell broke loose! The blowout preventer cut out and we just had to shut her down until we could get another pack-off out to the rig, put it on and tie down. *For three hours and fifteen minutes we kept our fingers crossed!* Then we began to empty the tubing. The UNAFLO flowed out of there just as easy as it went in!"

Anything can happen during a critical cementing operation. That's why so many operators *play safe* by using UNAFLO to protect their well investment. Try UNAFLO on your next job. For more details see the Composite Catalog of Oil Field and Pipe Line Equipment. Universal Atlas Cement Co. (United States Steel Corp. Subsidiary), Amicable Building, Waco; Tulsa; Oklahoma City; Kansas City; Chicago; and Birmingham.

AND HERE'S HOW TO SPEED UP SURFACE CEMENTING!

▶ *If you're looking for a way to save costly rig time without sacrificing safety and efficiency, your best bet is Atlas High-Early. It gains strength rapidly and thus speeds up cementing of surface and conductor pipe, and construction of rig foundations and cellars.*

PE-U-20

UNIVERSAL ATLAS OIL WELL CEMENTS

Running Tour

WITH MEN IN THE INDUSTRY

N. G. MOORE, general superintendent of the Pan American Pipe Line Company, died recently of a heart attack in Houston, Texas, where he resided. Burial was in Mooresville, North Carolina, his birthplace.

After graduating from North Carolina University in 1926, Moore went to work for Cities Service Oil Company as a junior engineer. He became pipe line superintendent in the Oklahoma City field, later being transferred to Gladewater, Texas. In 1931, he was made superintendent in the East Texas field for the Empire Pipe Line Company, a subsidiary of Cities Service. He accepted the post of general superintendent for Pan American September 1, 1940.

JUSTIN B. BRADLEY, Hornell, New York, prominent utilities executive, died March 28 in a Buffalo hospital, having been admitted to that institution March 11 after suffering a cerebral hemmorhage. Among other business interests, he was president of the Empire Gas and Fuel Company, Ltd., the Hornell Gas Light Corporation, the Empire Gas Appliance Corporation, the Empire Gas and Fuel Company of Pennsylvania, the Bradley Producing Corporation, and the Empire Producing Corporation. He was also a director of each of these units. He was a director and vice-president of the Producers Gas Company, a director of the Belmont Quadrangle Drilling Corporation, and a director of the Forest Oil Corporation.

GARMAN O. KIMMELL, of Black, Sivalls and Bryson, Inc., Oklahoma City, Oklahoma, addressed the Mid-Continent Section of the A. S. M. E. on April 14 at Tulsa, Oklahoma, his subject being "Test Procedure for Evaluating Distillate Well Properties."

L. I. MISTROT has been transferred from Longview, Texas, to Alice, Texas, by the Arkansas Fuel Oil Company. He is district petroleum engineer for the company at Alice.

LAWRENCE E. BROCK, JR., engineer, has been transferred from the division office of the Stanolind Oil and Gas Company at Fort Worth, Texas, to the general office at Tulsa, Oklahoma.

J. D. WHEELER, who has been division petroleum engineer at Houston, Texas, has been promoted to chief petroleum engineer by The Ohio Oil Company. His headquarters are at Findlay, Ohio.

SAM F. SHAKELY, petroleum engineer with The Carter Oil Company, is now acting in the capacity of scout in Indiana and Kentucky, making his headquarters at Evansville, Indiana. He was transferred from Tulsa, Oklahoma.

MARVIN YOCHES, apprentice engineer for the Phillips Petroleum Company, is now at Abbeville, Louisiana. He has been at League City, Texas.

HUGH F. CRAIN, formerly district clerk at Port Barre, Louisiana, for the Pan American Production Company, is now on leave of absence to resume studies in geology at Kansas University, Lawrence, Kansas.

JOHN E. MCKITTRICK, production engineer with the "Tex" Harvey Oil Company at Arroyo Grande, California, is now stationed in Dallas, Texas. He expects to be transferred to Palestine, Texas, in the near future.

WILLIAM H. TRIMBLE, JR., who until recently was a seismographer for the Gulf Research and Development Company, working with a crew near Guymon, Oklahoma, has resigned to accept a position as petroleum engineer with Ryder Scott Company, consultants, Bradford, Pennsylvania. Trimble is a graduate of the University of Pittsburgh.

S. F. SHAW, consulting engineer of San Antonio, Texas, left April 1 for the Turner Valley field, Canada. He will be gone several weeks, returning in time to deliver a lecture on gas-lift at the Texas University Chapter of the A.I.M.E., April 27.

J. C. CASLER has resigned as vice-president and general manager of the Joiner Oil Corporation, Dallas, Texas. He will operate as an independent, having opened an office at 1307 Kirby Building, Dallas.

ANDY J. BALCOM, general superintendent of the telephone and telegraph department of the Magnolia Petroleum Company, Dallas, Texas, has been named president of the Shrine Directors Association of North America.

FRANK PATTERSON of Midland, Texas, has been named field engineer for the K.M.A. Pressure Maintenance Association, Wichita Falls.

G. A. MABRY has been appointed assistant to H. C. Wiess, president of the Humble Oil and Refining Company, Houston, Texas, to handle newspaper and press contacts. At the same time, RICHARD J. GONZALEZ was placed in charge of correlating economic and statistical work for the company. Both activities previously had been under the supervision of W. N. FINNEGAN, JR., who resigned recently to enter the oil business for himself.

O. G. LEICHLITER, formerly vice-president and general manager, has been elected president of the Mudge Oil Company, Pittsburgh, Pa.

THOMAS BLACK, of Anglo-Ecuadorian Oilfields, Ltd., Guayaquil, Ecuador, has returned to the United States, accompanied by Mrs. Black and their daughter, Miss Eleanor Black.

THOMAS A. CREEKMORE, Tulsa, Oklahoma, has retired as president of the Summit Drilling Company because of ill health. He has been succeeded by JOEL A. WOLFE.

C. L. PFOUTS of Nichols Run, Pennsylvania, has purchased the Eli Tarr estate interest in 22 producing wells in Cattaraugus County, and will inaugurate a secondary-recovery project.

FRED WEST, Shreveport, Louisiana, supervisor of operations for Westbrook, Thompson and Stewart, has been transferred to Jackson, Mississippi.

F. C. BUCKWALTER has been made engineer of the Lucien district, Oklahoma, by Shell Oil Company, Inc.

J. D. TURNER, in the geological division of The Carter Oil Company, has been moved from Mattoon, Illinois, to Comanche, Oklahoma, to replace W. D. MCBEE, who has entered military service.

C. M. LALONDE has been made assistant to the district superintendent of the Phillips Petroleum Company at Great Bend, Kansas.

D. E. BUCHANAN, president of Hanlon-Buchanan, Inc., has accepted the general chairmanship of the entertainment committee for the Mid-Year meeting of the American Petroleum Institute, which will be held in Tulsa, May 19-22, inclusive.

RALPH S. COOLEY, for the last five years in charge of the West Texas-New Mexico district for The Sloan and Zook Company of Bradford, Pennsylvania, resigned his position with that company and opened an office in the First National Bank Building in Midland, Texas, on April 1 for George P. Livermore, Inc. Cooley will act as assistant to Livermore, devoting most of his time to exploration activities.

CHARLIE WILLIAMS, formerly with the company branch at Alice, Texas, has been transferred to the Odessa, Texas, branch by Black, Sivalls and Bryson, Inc. Williams will replace EARL DARR, who has been called for military service.

FRED JONES, materialman for Stanolind Oil and Gas Company, Brownfield, Texas, will join the U. S. Army shortly, and Mr. Ship, employed by Stanolind at Iraan, Texas, will be moved to Brownfield to take the place of Jones.

DIXIE MORRIS will be transferred by the Union Producing Company from Houston, Texas, to Southwest Texas within the next few weeks. This transfer was made necessary by the fact that the Union Producing Company lost two Southwest district men to the Army.

H. B. PEACOCK of Geophysical Service Incorporated has been elected president of the Society of Exploration Geophysicists for the coming year. FRANK GOLDSTONE of Shell Oil Company, Inc., is the new vice-president, and W. M. RUST, JR. of Humble Oil and Refining Company, was elected secretary-treasurer. RALPH D. WYKOFF of Gulf Research and Development Company, Pittsburgh, Pennsylvania, was reëlected editor.

R. E. SPENCER GEARE is now connected with Thermoid Rubber Division of Thermoid Company, Trenton, New Jersey, according to an announcement by F. E. SCHLUTER, president. Geare is well known throughout the industry as an authority on V-belts, V-belt drives, and power transmission, and has specialized in that field for the last ten years. During the last 25 years he has held sales and engineering executive positions with several well known companies. Geare's association with Thermoid is part of that company's program of improvement and expansion of its industrial rubber products line. He will concentrate on the improvement of Thermoid's multiple V-belt and F.H.P. belt programs and the expansion of V-belt sales.

MAX W. BABB, president of Allis-Chalmers Manufacturing Company, announces the appointment of LEE H. HILL, widely known transformer engineer, as assistant manager of the company's Electrical Department. Hill has been head of the company's Transformer Department since 1936, and will now assume, among other duties, general supervision of the Electrical Department's sales promotional activities, with particular reference to developing public utility business.

WILLIAM WATSON, vice-president and general manager of the Allis-Chalmers Manufacturing Company, announces the appointment of JAMES M. WHITE as assistant general works manager, who was formerly manager of the company's La Porte Works, a post he held for the last six years.

CARL J. TURNER, representative of Spang and Company, Butler, Pennsylvania, for the last 28 years, in the Pennsylvania-New York-Ohio and West Virginia fields, died at his home in Butler on March 11. Funeral services were held at the Dengler Funeral Home, Butler, on March 14.

LEO RANNEY paid a visit to Dallas and Fort Worth during the early part of April. He delivered a paper on "Drilling Wells for Oil or Water Horizontally" before the Fort Worth Petroleum Engineers Club, April 7.

WALLACE E. PRATT, a director and member of the executive committee of the Standard Oil Company of New Jersey, gave a series of four lectures on petroleum geology before the students and faculty of the departments of geology and petroleum engineering of the University of Kansas, March 17, 18, and 19. The subjects of his lectures were "Oil in the Earth," "Where Oil Is," "Who Finds Oil—And How," and "Oil and Human Culture." Pratt is an alumnus of the University of Kansas and a past president of the American Association of Petroleum Geologists.

HARRY J. SCHEIDT, a graduate of Brooklyn Polytechnic Institute and recently associated with Williamsburgh Power Plant, has joined the engineering department of Northern Equipment Company, Erie, Pennsylvania.

R. S. MARTHENS, formerly manager of the Westinghouse Gearing Division has been appointed staff assistant to the manager of the Canton Ordnance Division, it is announced by F. D. NEWBURY, vice-president of the company. The Canton plant, which is under construction at present, will, when completed, be operated by Westinghouse and owned by the U. S. Government.

WILLIAM G. THEISINGER, who since 1935 has been welding and metallurgical engineer of Lukens Steel Company, Coatesville, Pennsylvania, has been appointed director of welding research of the concern.

G. D. GROCE, formerly of Cleveland, Ohio, has been appointed general service manager of the Buda Company, Harvey, Illinois, it has been announced by R. K. MANGAN, executive vice-president. Groce has been connected with the automotive industry in a manufacturing and engineering capacity for many years and during the last ten years was service manager of the Cleveland Tractor Company. He has traveled extensively in the United States and abroad. He and his family will reside at Olympia Fields.

E. C. BYNUM has been appointed district manager for East Texas by Atlas Supply Company, succeeding E. B. RAINEY, resigned. Bynum will have charge of Atlas stores at Gladewater, Kilgore, and Overton, Texas. He has been with Atlas approximately ten years. The Gladewater store remains in charge of GEORGE R. DONNELLY, assisted by R. D. DICKINSON and PAT MASSEY. C. H. COLLIER has been made manager of the Kilgore store. RAY ESTES succeeds Bynum as manager of the Overton store, and will be assisted by J. H. MCCRARY. L. S. HENSY continues as district sales engineer.

E. C. BYNUM

BOB SIVALLS will return to take charge of the Jackson, Mississippi, branch, after spending some months in charge of the Black, Sivalls and Bryson, Inc., branch at Ardmore, Oklahoma. Sivalls was formerly in charge of the Jackson branch. He will be replaced at Ardmore by Ed Nelson, formerly with the home sales office of the company at Oklahoma City.

These Patterson-Ballagh Protectors good for 100,000 feet of hole

Five Texas wells, each more than 11,000 feet deep, were drilled with the Protectors shown in these unretouched photos. The Protectors are still in prime condition and show no loss in diameter. The drillers estimate they are good for at least five or six more wells —a total of more than 100,000 feet of hole. That's a lot of hole—and a lot of service from one string of Protectors. Only the toughest kind of rubber can render such service. Patterson-Ballagh rubber can take punishment! It's compounded by exclusive Patterson-Ballagh methods.

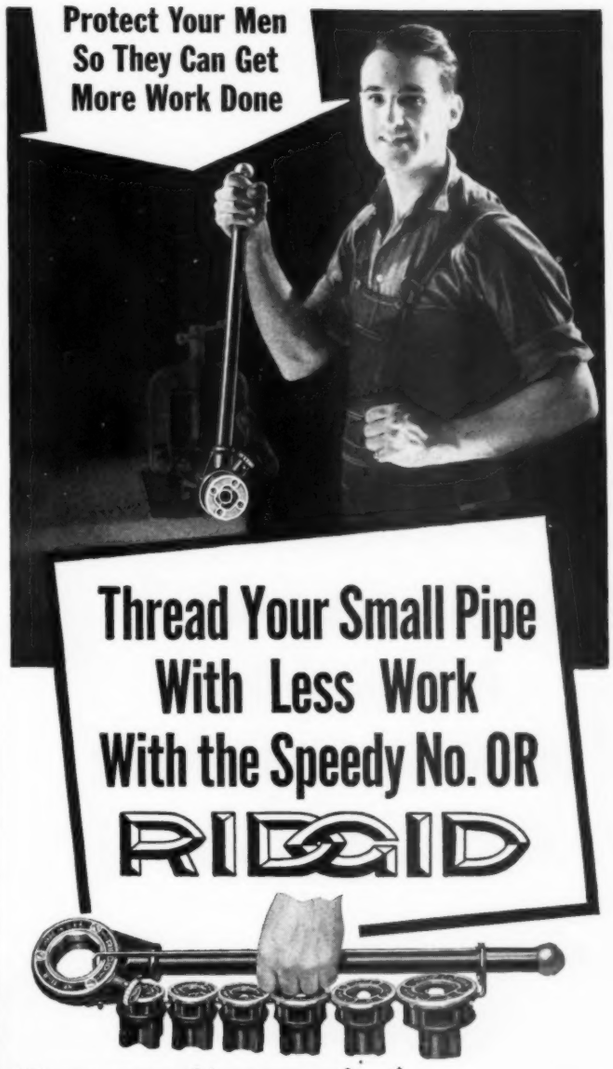
For longest life to your drill pipe choose the Protectors that have proved their endurance

PATTERSON-BALLAGH PIPE & CASING PROTECTORS

See Composite Catalog

PATTERSON-BALLAGH
CORPORATION

Los Angeles Houston New York City



Thread Your Small Pipe With Less Work With the Speedy No. OR RIDGID

Minutes count this year — and avoidable motion wastes manpower. Speed your small pipe threading with these work-saver ratchet dies. Die heads snap instantly into ratchet ring from either side, can't fall out. And push out easily for changing.

Dies reverse quickly for close-to-wall threads, no special dies you can't find when you want them. Handy patented die carrier with each set.

Save valuable time and effort —buy easier-working RIDGIDs at your Supply House.

THE RIDGE TOOL COMPANY
ELYRIA, OHIO

Die heads push out readily for changing.

Dies reverse quickly for close-to-wall threads — no special dies needed. Long wear dies, easily reground.

RIDGID
***WORK-SAVING* PIPE TOOLS**

LAUGH WITH BARNEY

An old negro was complaining that the railroad would not pay him for his mule, which it had killed—nay, would not even give him back his rope.

"What rope?" he was asked.

"Why, sah," he answered, "de rope dat I tied de mule on de track wif."

* * *

James Simmons, representative at Corpus Christi, Texas, for Hanlon-Waters, Inc., says this story is going the rounds of the supply stores in his territory:

There was a young man who had never had any experience in any kind of work outside a gasoline service station. He lost his job and the only thing that he could find in the way of a job was in a cafe. He spent the first day acquainting himself with the slang expressions used by the other waiters when they turned an order in to the cook. Finally he decided to take a chance on it.

Approaching a customer he asked him what he would like to have. "Bowl of chili without beans," replied the customer. The beginner turned toward the kitchen and bawled out: "Bowl o' red, make it anti-knock."

* * *

"Lil told me that you told her that secret I told you not to tell her."

"The mean thing! I told her not to tell you."

"Well, I told her I wouldn't tell you that she told me, so don't you tell her I did."

* * *

"I have a husband who is rich;
He adds much to my life.
He buys me everything I want—
But please don't tell his wife."

* * *

"Do you suppose it's bad luck for a cat to follow you?"

"It all depends; are you a man or a mouse?"

* * *

Bulletin in Scotch church: "Those in the habit of putting buttons instead of coins in the collection plate will please put in their own buttons and not buttons from the cushions on the pews."

* * *

One man, talking to another, asked if he knew anything about the lie detector the papers talk so much about.

The other replied: "Yes, I married one."

* * *

Up in the Northwest, the train was stuck in the snow. One of the passengers saw a farmer poking a stick in the snow, and asked him how deep it was. The farmer replied: "Damfino; I'm hunting for my barn."

* * *

You have all heard of the Scotchman who wouldn't buy his girl a parasol when he took her to the beach, but told her shady stories instead.

* * *

At a particularly loud clap of thunder, a lady walking along a London street involuntarily and visibly started. "It's all right, lidy," said a passing urchin. "It ain't 'itler, it's Gawd."

* * *

Two drunks: "We must be nearing a town—we're running over more people."

* * *

It was a beautiful spring morning and the cute little baby bird crawled up on the edge of his nest, chirped twice, spread his wings and took off. He was gone over an hour and Mother was anxiously waiting when she saw him limping in, one wing down. His beak was battered, one eye blacked, his tail feathers broken and drooping.

"Where in the hell have you been?" asked Mother.

Hanging his head the little birdie replied, "I was flying back through the park and got mixed up in a badminton game."

* * *

It's pretty hard to keep up with the Joneses if they happen to be newlyweds.

* * *

"See that bevy of quail in the underbrush?"

"Yes."

"Well, watch me shoot a hole clear through the red barn behind 'em."

* * *

After coming in from a 20-mile hike the officer in command of a negro company said, before dismissing them:

"I want all the men who are too tired to take another hike to take two paces forward."

All stepped forward except one big husky six-footer.

Noticing him, the officer said:

"Well, Johnson, ready for 20 miles more?"

"No, sah," replied Johnson, "Ah'm too tired to take dem two steps."

* * *

Girls: Creatures who are fond of pretty clothes, but are not necessarily wrapped up in them.

A girl's voice was heard in a bomb shelter: "Get your dirty hands off my knee. No, not you . . . YOU!"

* * *

No farmer whose cow has had the colic can understand how some radio crooners can get $1,000 a week for making the same noise.

* * *

Wife: My husband has no bad habits whatsoever. He never drinks and he spends all his evenings at home. Why, he doesn't even belong to a club.

Visitor: Does he smoke?

Wife: Only in moderation. He likes a good cigar after he has a good dinner, but I don't suppose he smokes two cigars a month.

* * *

Lord give me grace to catch a fish
So big that even I,
When talking of it afterwards
May never need to lie.

* * *

A man who was riding on a train through western ranch country aroused considerable interest among passengers in adjoining seats. As they sped along past vast cattle ranches, the man jotted down figures on a paper. Finally, one curious man asked what he was doing.

"Well, you see," he explained, "I have a cattle ranch in New Mexico, and I'm checking up on the stock these Texas ranchers keep."

The curious one looked at the paper, and sure enough, he saw a neat row of figures—472, 500, 316, 724. He was amazed, and asked, "Do you mind telling me how you can possibly count the cattle at each ranch as we whiz by at this speed?"

"That's easy," said the rancher; "I just count the legs and divide by four."

* * *

There aren't any swear words in the Japanese language. No wonder they want to fight.

* * *

The engineer had become tired of the boastful talk he had heard from the other engine drivers at his boarding house. One evening he began: "This morning I went over to see a new machine we've got at our place, and it's astonishing how it works."

"And how does it work?" asked one.

"Well," was the reply, "by means of a pedal attachment a fulcrumed lever converts a vertical reciprocating motion into a circular movement. The principal part of the machine is a huge disk that revolves in a vertical plane. Power is applied through the axis of the disk, and work is done on the periphery, and the hardest steel by mere impact may be reduced to any shape."

"What is this wonderful machine?" he was asked. "A grindstone," was the reply.

There is

A TYPE OF BAKER SHOE OR COLLAR to meet every requirement in Landing & Cementing Casing

Regardless of the depth of well and hole condition, there's a type of Baker Shoe or Collar that will insure the *Safe Landing and Proper Cementing* of your casing string.

Whether your problem is one of landing and cementing a long, heavy string in a record depth well; cementing a short string in shallow depths; or of getting a string to bottom in heaving or caving formation, there is a particular type of Baker Cement Guiding, Floating, Cementing Equipment unit designed to do the job safely, efficiently, and economically . . . plus the fact that when the casing is landed and efficiently cemented, Baker Shoes and Collars can be quickly and easily drilled out. Only easily drillable materials are ever used for the internal construction of Baker Cement Equipment units.

Convenient Stocks

For convenience of operators, when time means money, adequate stocks of popular sizes of Baker Cement Guiding, Floating, Cementing Equipment units are maintained at strategically located points in all fields throughout the United States.

For sales, service, or information, concerning Baker equipment, contact the nearest Baker office or representative. Complete details are given on pages 217 to 227—1941 Composite Catalog.

BAKER CEMENT GUIDING, FLOATING, CEMENTING EQUIPMENT

BAKER OIL TOOLS, INC.

Main Office and Factory:
6000 So. Boyle Ave.
P. O. Box 127, Vernon Station
Los Angeles, California
Central Division Office and Factory:
6023 Navigation Blvd.
P. O. Box 3048, Houston, Texas
Export Sales Office:
19 Rector St., New York, N. Y.

Operators WHO WANT TO BE "SURE" USE THE . . .

BAKER CEMENT WASH-DOWN WHIRLER FLOAT SHOE
(Product No. 120)

and HERE'S WHY . . .

★ It will safely guide and float the longest and heaviest string of casing.

★ It has a positive-acting BALL-TYPE Back-Pressure Valve.

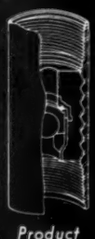
★ It provides WHIRLING ACTION which assures best possible cement distribution at the shoe joint with minimum hazard of channeling.

★ It affords easy drillability.

Baker Cement Float Shoe

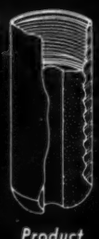
Baker Cement Float Collar

Product No. 100



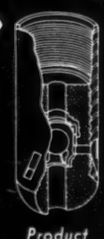
Product No. 101

Baker Cement Guide Casing Shoe



Product No. 102

Baker Cement Wash-Down Whirler Float Shoe



Product No. 120

Baker Cement Wash-Down Whirler Guide Shoe

Product No. 121

Baker Cement Whirler Float Collar with Solid Bottom Baffle with Metal "Petal" Basket

Product No. 306

MACHINERY and EQUIPMENT

Hydril Blowout Preventer

AN ADDITION to the line of Type "R" blowout preventers is offered by the Hydril Company, 714 West Olympic Boulevard, Los Angeles, California. The new blowout preventer, designated the No. 3 size, is designed for use as a primary blowout preventer and can be used with auxiliaries such as ram-type control equipment of all kinds as well as the larger models in the Type "R" line.

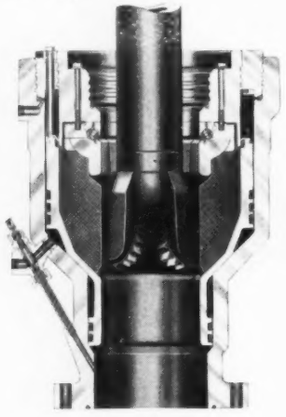


Fig. 1. Bit passes through packing unit without removal of parts

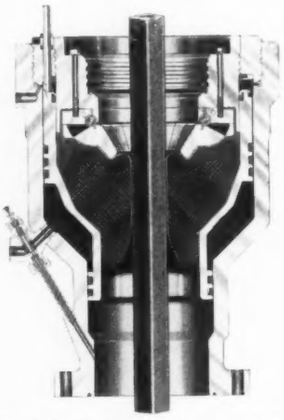


Fig. 2. Packing unit seals on any kelly or other member of drill string

HYDRIL NO. 3 TYPE "R" BLOWOUT PREVENTER

Packing units with bores of various sizes are supplied to give the pack-off range required by particular conditions. The packing unit with 10-in. bore will allow the passage of bits and tools used in 11¾-in. casing, and will seal-off around drill-string members from 9⅞ in. to 3½ in. O.D. When the packing unit with 8¾-in. bore is used, bits and other tools that will run inside of 9⅝-in. casing will pass through the blowout preventers. This packing unit seals around drill-string members as small as 2⅜ in. O.D.

A large reserve of material is provided in the packing unit to withstand wear occasioned by the rotation of the kelly or drill pipe, and by stripping tool joints, casing protectors, and other large-diameter parts of the drill string under pressure.

The blowout preventer head is equipped with lugs for attaching a special kelly packer. This assembly packs-off either the square or hexagonal kelly and permits prolonged drilling under pressure without imposing undue wear on the packing unit of the blowout preventer.

Buckeye Unitilt Bulldozer

THE BUCKEYE Traction Ditcher Company, Findlay, Ohio, announces the development of new Buckeye Unitilt cable-controlled bulldozers and trailbuilders for all makes and models of tractors. The name of the new design is derived from the patented tilting device and the *universality* of the frame, which permits using either Buckeye bulldozer or trailbuilder moldboards on the same frame. This latter feature eliminates the initial investment in two frames that formerly was necessary in order to have both bulldozer and trailbuilder, and further simplifies changing-over. One man can change moldboards, which can be dismounted from the tractor by pulling two kingpins. The sidearms and other parts stay in place.

The tilting device is situated on one sidearm and permits raising or lowering bulldozer or trailbuilder blade at either end a distance of 12 in. Turning one bolt only is all that is required to effect the tilting adjustment.

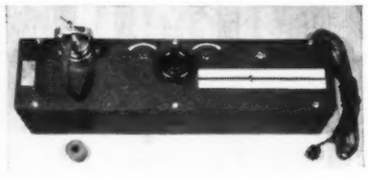
The manufacturer asserts that other features of the new design include: construction of the front cross beam so that the blades hug the radiator, thus reducing the heavy overhanging load on the front of the tractor and reducing wear on front idlers and track

rolls; blade curvature that *rolls* the dirt ahead, reducing "dead" weight and permitting greater loads in front of the blade; 60-in. lift of blade and unlimited depth of cut below ground level; natural digging action of blade that cuts as deep as the operator desires without requiring any mechanical means of creating down pressure; balanced design that prevents tipping of tractor and keeps full length of crawlers on the ground; sidearms mounted at drive axle of tractor; rigid, fully braced members to withstand all types of 'dozing work.

Literature and specifications on the Buckeye Unitilt equipment will be available on request from the manufacturer.

Hayward Permeameter

ENGINEERING Laboratories, Inc., 624 East Fourth Street, Tulsa, Oklahoma, offers a new type permeameter operating on what the manufacturer states is a different principle than any similar equipment now available for core analysis determinations.



Standard rubber bushings, containing the core sample, are quickly clamped into the permeameter core

holder. A handwheel is turned in the direction indicated by the pilot lights. This is the only manual operation; there are no gauges or meters to watch.

Permeability of the core is read directly in millidarcys and *no calculations are required* if a standard core size is employed. For odd-shaped samples one determines permeability by a single multiplication with the length-area ratio.

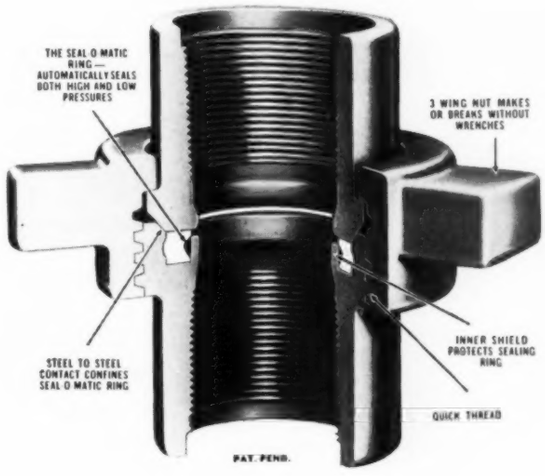
This permeameter is entirely independent of variations that require careful consideration in the classical method of permeability determination. Sensitivity and accuracy are comparable with meters now in use. The instrument is inherently free from variations in humidity and temperature. No liquids are employed and leveling is irrelevant. Airflow through the sample remains in the laminar region without attention of the operator.

Seal-O-Matic Quick-Change Union

UTILIZING the force of pressure to effect a seal automatically has been accomplished by Guiberson in the new Seal-O-Matic Union, officials of the company state. This self-sealing action is attained by means of a flexible, molded, oil-resisting Seal-O-Matic ring.

A positive seal is attained independent of the tightness of the wing nut, it is said. Field replacement of the ring is easily accomplished. Maximum misalignment of the union will not disturb the seal. Hubs are turned from special high tensile solid steel bars.

The principle of operation has been thoroughly field-tested on the quick-change union used with the Guiberson Type "H" drilling head, the manufacturer asserts. In repeated hydrostatic tests, a 2-in. stock Seal-O-Matic Union has passed the test of 19,500-lb. pressure per sq. in. Exacting inspection failed to disclose damage to either the flexible sealing ring or the union. The union is available in 2-in., 2½-in., 3-in., and 4-in. sizes from The Guiberson Corporation, Dallas, Texas.

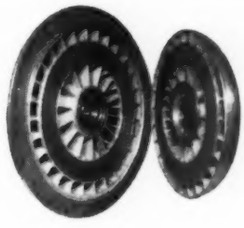

THE SEAL O MATIC RING — AUTOMATICALLY SEALS BOTH HIGH AND LOW PRESSURES
3 WING NUT MAKES OR BREAKS WITHOUT WRENCHES
INNER SHIELD PROTECTS SEALING RING
STEEL TO STEEL CONTACT CONFINES SEAL O MATIC RING
QUICK THREAD
PAT. PEND.

CHICAGO FLOATING SWING BRIDGE HAS SMOOTH FLUID DRIVE

Chicago's 130th Street traffic is moving more steadily, with shorter waits at the Calumet River Bridge for boats —thanks to Fluid Drive!

The American Blower Fluid Drive (Hydraulic Coupling) is installed between the gasoline engine and gear box that delivers power to the winch for the 105-ft. pontoon swing span. Operators can now control the bridge movement entirely by regulating the engine throttle and without manipulating the drum clutches of the winch.

Engine stalling and clutch burnouts are eliminated. The cables, machinery and engine are protected from sudden jerks and stresses. Handling of the bridge is simplified and speeded up . . . All by the American Blower traction type Fluid Drive!



Fluid Drive

(HYDRAULIC COUPLING)

If you are interested in improving the performance of your Diesel-powered drill rigs — if a practical means of speed control that also smooths out torque fluctuations, protects engines, machinery and cables from sudden shocks and overloads, would save you time and money — get the facts on the Fluid Drive (Hydraulic Coupling). Phone or write the nearest American Blower branch office today for complete data.

AMERICAN BLOWER CORP.

HYDRAULIC COUPLING DIVISION, 6000 Russell St., Detroit, Mich.

LAB Proportioning Pumps

THE Transmission Engineering Company, 259 Second Street, San Francisco, California, announces its entry into production of the new stream-lined and weatherproof LAB Proportioning Pumps under a license agreement with the Shell Development Company who have used them for a number of years and who hold the patents on the designs.

As illustrated, all working parts are totally enclosed in a cast-iron, sealed housing with a built-in, submerged lubricating system, having an external oil level indicator.

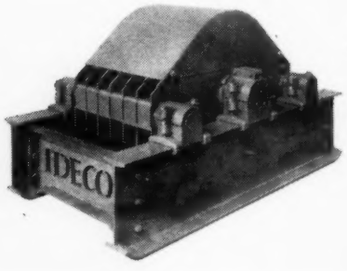
With the horizontal pumping end removed from all other working parts the units can be economically supplied in any required alloy, the manufacturer states. Any number of units can be connected in parallel to a single driving motor and a clutch mechanism permits the release of any unit without otherwise interrupting the service. The stuffingbox is very accessible and any leakage does not come in contact with any parts of the unit.

Length of stroke is adjusted from maximum to minimum by merely turning the handwheel, with an indicating mechanism showing the relative capacity.

Sizes have been developed to cover a range of capacities varying from zero to 360 gal. per hour and for pressures to 300 lb.

Ideco Giant Crown and Traveling Blocks

IDECO announces the addition to its line of drilling blocks of the new Ideco giant crown and traveling blocks. Ample capacity is provided in these blocks for drilling in excess of 15,000 ft., it is stated. The giant size 48-in. sheaves, mounted in heavy-duty roller



$2\frac{1}{4}$" I.D.
Exactly one-half the diameter (4½") of the drill pipe.

8" O.D.
When installed on pipe
9" O.D.

WHY THEY GIVE BETTER PROTECTION AND REDUCE DRILLING COSTS

Grizzly "Hug-Tite" Protectors and Stabilizers are made with a much smaller inside diameter than heretofore has been possible . . . for example, 2¼" I. D. and 8" O. D. for use on 4½" drill pipe. When installed on the pipe the inside diameter is 4½ inches, and the outside diameter 9 inches; being expanded 100% on the inside, but only 12½% on the outside. The stretch imposed on the inside diameter when protector is placed on pipe provides a tremendous gripping power that eliminates any possibility of moving from installed position, while the outside diameter remains under very little tension and will not tear or break under heavy impact. . . . This advanced construction plus hydraulic installation insures full protection all the way to bottom and saves thousands of dollars on each well in drill pipe, tool joints, casing, labor, and overall drilling costs. Ask your supply dealer for detailed information, or write for Bulletin No. 21-OF.

E. M. SMITH COMPANY
600-650 South Clarence St., Los Angeles, California, U. S. A.
Complete Stocks Maintained in Our Warehouses At:
407 Velasco Street, Houston, Texas
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Distributed by Leading Supply Companies

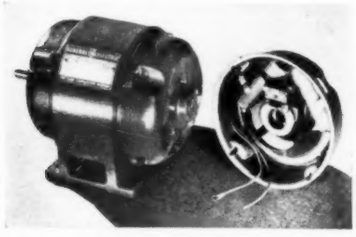
GRIZZLY "HUG-TITE"
DRILL PIPE PROTECTORS & STABILIZERS

bearings and individually lubricated, provide a large radius that reduces the bending stress and increases the life of the wire rope. The traveling block is of the over-balanced type and is proportioned to prevent overturning and fouling of the lines when the block is lowered. Sheaves and bearings are interchangeable in these two blocks. The equipment is offered as five or six sheave crown block and five sheave traveling block. Sheaves are of chrome-nickel, chrome-nickel "hi-temper" groove, or manganese steel.

For further details write The International Derrick and Equipment Company, Beaumont, Texas.

G-E. Tri-Clad Capacitor Motor

AS AN extension of its recently announced line of new polyphase induction motors, General Electric Company, Schenectady, New York, now offers a new Tri-Clad capacitor motor



New General Electric Tri-Clad capacitor motor. The end shield to the right of the motor shows the location of the capacitors and transfer switch.

designed to meet a large number of varied industrial applications. Like the polyphase Tri-Clad motor, this capacitor motor features modern appearance, and better mechanical and electrical protection as well as protection against operating wear and tear.

The new capacitor motor may be obtained with either ball-bearing or sleeve-bearing construction, and is available in two types, Type KC and Type KCJ. The Type KC is designed particularly for applications requiring moderate starting torques such as fans, blowers, and centrifugal pumps. The Type KCJ is designed for compressors, loaded conveyors, reciprocating pumps, and any other applications requiring high starting torque. The capacitors are mounted inside the end shield on the normal-torque motor, whereas on the high-starting torque motor, 1½ hp. and larger, the capacitors are mounted in a compact case on top of the motor frame.

In both of its forms, the capacitor motor incorporates all the protective features of the Tri-Clad line: (1) complete mechanical protection through the use of a cast-iron frame, (2) electric protection made possible by the use of Formex wire in the magnet coils, and (3) improved bearing design and lubricating arrangements. It also utilizes the cast-aluminum rotor and double-end ventilation. In addition, it offers many convenient features.

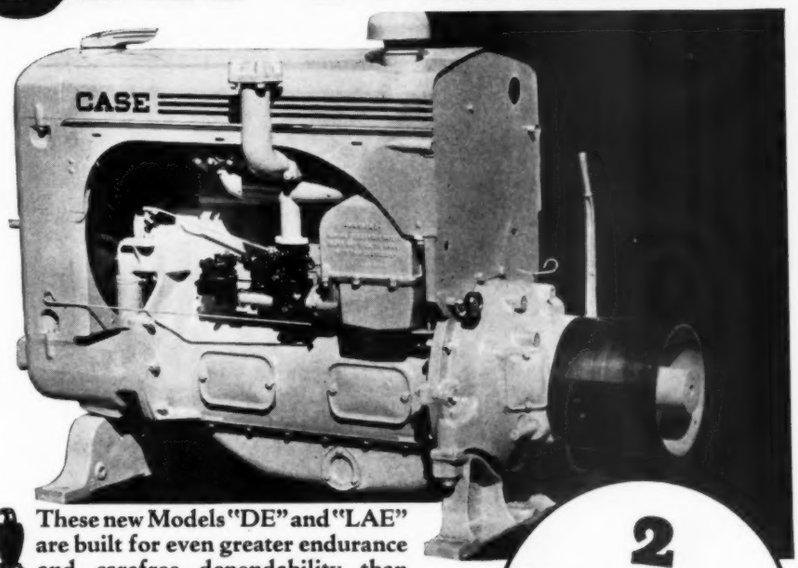
The protected frame and end shields minimize contact of vital motor parts with foreign material at the same time protecting it against accidental blows in handling or similar rough usage. The new-type Formex insulation, dust-tight bearings, and the use of Glyptal in the priming and finishing paints armor it against the attack of harmful agents.

The transfer switch is a simple, sturdy device that transfers the motor from the starting to running connection. It consists of a centrifugal mechanism mounted on the rotor shaft, and a stationary switch situated in the end shield. As the motor approaches full speed, centrifugal force moves the collar of the rotating mechanism away from the switch by snap action, thus causing the switch to open.

A new pressed-steel conduit box provides unusually large working space and simplifies installation in close quarters. The box may be mounted in any one of four positions.

Clearly marked terminals permanently identify the leads. A graphic, easy-to-read connection plate of stainless steel shows external connections.

Pumping Power
STEPS AHEAD



These new Models "DE" and "LAE" are built for even greater endurance and carefree dependability than prior models which made oilfield history. New radiators give greater reserve of cooling capacity for summer heat. Improved oil pump, strainer, and delivery ducts insure positive oiling under wider extremes of heat and cold. Four-ring pistons divide ring wear, defer ring replacement. Case-built, full-sealed magneto offers the utmost in dependable ignition. Case-built oil-bath air cleaner and new long-lived shaft seals guard entire engine against dust. Automatic cut-outs prevent damage if engine temperature goes up or oil pressure goes down. Get full details from your distributor.

J. I. Case Co., Racine, Wis.

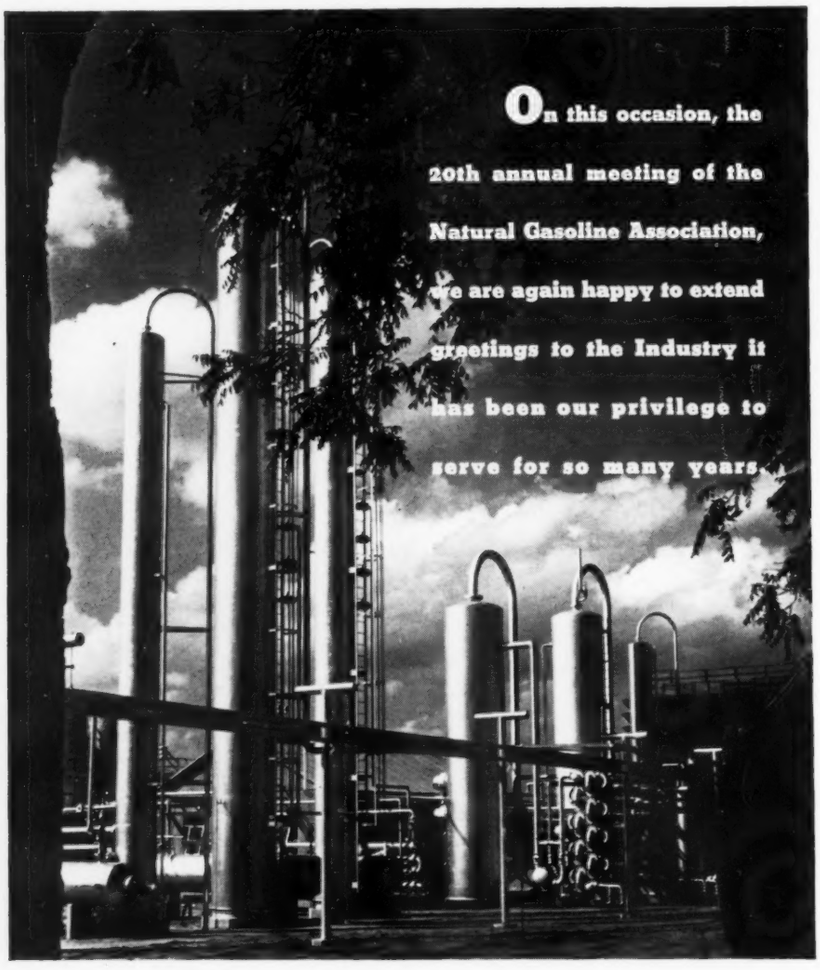
CASE
Oil Field Engines

2 Brand-New Models

DISTRIBUTORS
Southwest Equipment Co.
Dallas and Kilgore, Texas
Leland Equipment Co.
Tulsa, Oklahoma
Howard Supply Co.
Los Angeles, Calif.

Liquefied Petroleum Gas Storage

ALMOST 40 percent of the tanks utilized for liquefied petroleum gas storage by the General Gas Corporation in 12 Louisiana cities were supplied by the Chicago Bridge and Iron Company. The two tanks shown here are at Baton Rouge. General Gas Corporation purchases all its liquefied petroleum gas from Warren Petroleum Corporation.


On this occasion, the
20th annual meeting of the
Natural Gasoline Association,
we are again happy to extend
greetings to the Industry it
has been our privilege to
serve for so many years.

NATURAL GASOLINE EQUIPMENT

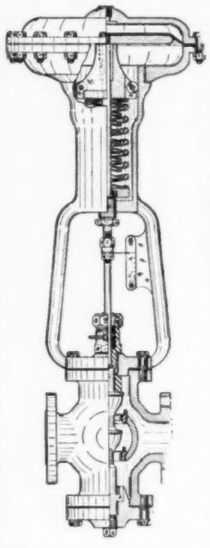
TULSA TYPE Built RIGHT!

Tulsa Boiler & Machinery Co.

WEST TWENTY-FIRST STREET & UNION AVENUE TULSA, OKLAHOMA

Hanlon-Waters Type 86 Motor Valve

A NEW Type 86 Motor Valve has been announced by Hanlon-Waters, Inc., Tulsa, Oklahoma, as the latest addition to their line of specialized control equipment.



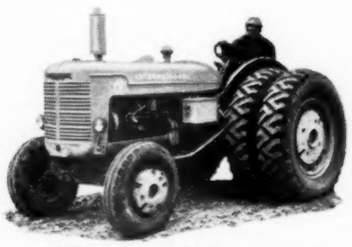
Among the features incorporated in the equipment are an improved top and bottom guided inner valve structure; top works of advanced design with upper guiding obtained from frictionless rollers running inside the enclosed spring barrel on a concentric machined surface. Positive alignment is maintained between the diaphragm plate and the stuffing-box by means of this improved roller guide, thus assuring positive and even action for variations of diaphragm pressure.

The yoke is styled with ample room to facilitate repacking the stuffingbox or mounting attachments. The travel indicator shows the travel in inches from the closed position on the scale plate mounted on the yoke arm. Minimum body restriction permits the inner valve to dominate the flow through full travel.

Inner valves are of the high parabolic type and are fully reversible in the field without the use of special tools or additional parts, it is stated. The Type 86 Motor Valve is available with iron or steel bodies and with a number of inner valve and seat materials. Flanging of any series and some bodies with special flange facings are available from stock.

Five New Industrial Wheel Tractors

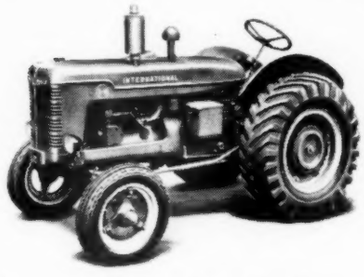
INTERNATIONAL Harvester Company's latest additions to its line of equipment for those who use industrial power are five new wheel tractors.



International Model ID-9 industrial wheel tractor

The tractors are designated as the "I" line and include three models with carburetor-type engines and two with International's quick, easy starting, full-Diesel engines.

All the five new tractors have Tocco-hardened crankshafts, pressure lubrication, replaceable cylinders, five forward speeds to 15 miles per hour (except the I-6 and ID-6, which have five speeds to 14 miles per hour), gear



Model I-4 Diesel wheel tractor

drive, countershaft brakes that can be individually controlled or interlocked, provision for mounting a variety of allied equipment, and various other features.

The three tractors with the carburetor-type engines are, respectively, designated as Models I-4, I-6, and I-9. The engines are of the 4-cylinder, valve-in-head type. The engine of the I-4 develops 29.5 hp. at rated governed speed of 1650 r.p.m.; that of the I-6, 40.5 hp. at rated governed speed of 1450 r.p.m., and that of the I-9, 54 hp. at rated governed speed of 1500 r.p.m. The bore and stroke of the I-4 are 3⅜ by 4¼ in.; of the I-6, 3⅞ by 5¼ in.; of the I-9, 4.4 by 5.5 in.

The two new Diesel-powered tractors are, respectively, designated as the ID-6 and ID-9 and in dimensions and other characteristics, excepting engines, are similar to the I-6 and I-9. The Diesel engine of each tractor not only uses low-priced fuel but also uses much less fuel than a conventional engine of the same size, according to the manufacturer, and, like all International Diesels, it can be started as easily as a conventional engine of corresponding size. It starts as a gasoline engine and is quickly converted to full Diesel operation by means of a level within easy reach of the driver.

The engine of the Diesel ID-6 develops 38.5 hp. at rated governed speed of 1450 r.p.m., and that of the Diesel ID-9 develops 51.5 hp. at rated governed speed of 1500 r.p.m. The bore and stroke of the ID-6 are 3⅞ by 5¼ and of the ID-9, 4.4 by 5.5 in.

The five new International industrial wheel tractors are capable of operating a variety of equipment in their power range. This includes maintainers and graders; front-end shovels and loaders; cross walk, side walk, and other types of snow plows; road rollers; cranes and hoists; winches; brushes and sweepers; disk harrows and mixers for mixed-in-place roads; scrapers; dump wagons; trailers; tampers; mowers, etc. Illustrations show the new International Model ID-9 industrial wheel tractor and new Model I-4 Diesel wheel tractor. Both are included in the new line of five streamlined International industrial wheel tractors.

A "PRIZE PACKAGE"
PROTECTS This BETTER WIRE ROPE!

Every reel protecting Union's high quality wire ropes is as carefully made as the rope itself. The strength of heads, rigidity of connections, and use of only smooth-faced drums —all together form a reel built to prevent damage to the rope through shipment or handling. All known precautions are taken to insure perfect Union Wire Rope for all orders. 6

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GENERAL OFFICES AND FACTORY:
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Tulsa • Houston • Chicago • Salt Lake City
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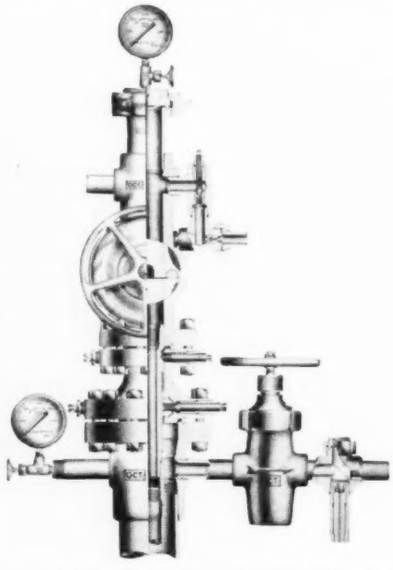
UNION Wire Ropes
The "ULTIMATE LOW COST WIRE ROPE"

O-C-T Christmas Tree Assembly

THE O-C-T Christmas tree assembly shown herewith in cross-section employs several unusual mechanical features.

Foundation for the assembly is provided by an O-C-T Type T-20 tubinghead with Type F-1 attachment Note that the Type F-1 attachment features retractable tubing hanger seats and lock-down screws in its lower and upper flanges, respectively. The retractable hanger seats permit tubing collars and tubing hanger to pass through the head to facilitate washing behind liner and setting packer. After drilling plug or gun-perforating, a few joints of tubing with liner and packer made-up on the first joint are lowered in the hole through the tubinghead body. The Christmas tree, made-up on the top connection of the Type F-1 attachment, is then stripped over the tubing and made-up on top of the tubinghead body. From this point on, the tubing is run through the entire Christmas tree manifold. An O-C-T stripper rubber-type blowout preventer is usually installed on the top of the Christmas tree to provide blowout protection while tubing is being run and landed, the tubing collars and hanger readily passing through the stripper-type pack-off. The blowout preventer also serves as a stuffingbox while washing behind the liner. After washing behind liner and setting packer, tubing is raised to suspension point and the retractable seats are screwed-in to engage the hanger. Lock-down screws are screwed-in to hold the hanger down securely on the seats. Weight of the tubing string expands a packing ring on the hanger to effect a seal.

Note in the illustration of the Christmas tree assembly the O-C-T cylinder gate valve flanged above the tubinghead. Obviously, this valve readily



passes the tubing hanger. Particular attention is directed to the extended cross made integrally with the valve body that eliminates a separate flow cross.

The O-C-T Type FT-816-N flow tee shown screwed into one side of the extended valve end is of entirely new design. Note that it embodies a needle valve and positive choke assembly in a single compact unit, thus eliminating a conventional gate valve and separate choke assembly.

The O-C-T Type B-10-A bottom-hole test adapter provides a proved safe fast connection on top of the Christmas tree, the manufacturer states.

The diagram also illustrates the use of an O-C-T cylinder gate valve on the casing outlet of the tubinghead with an O-C-T flow cross, cage nipple, and flow bean assembly installed to the right of the valve. This assembly provides safe control while the well is being washed into production. Note that the O-C-T Type FC-102 flow cross, like the bottom-hole test adapter, is provided with a quick change cap to permit speedy replacement of the flow bean when required.

SAVE ON EVERY TON-MILE

For real pulling power TWO driving axles under the load are far better than one.

With the THORNTON four-rear-wheel DRIVE, in addition to increased capacity and traction you get more flexible operation since you have two transmission ratios—one for power and one for speed. Your investment in equipment is 25 to 40% less, your operating and upkeep costs are from 30 to 50% lower. With THORNTON "Walking-Beam" spring design less shock reaches vehicle and load.

We can show you how to save with a truck equipped with THORNTON four-rear-wheel DRIVE. Users in scores of industries are lowering costs.

THORNTON TANDEM COMPANY

8701-8779 GRINNELL AVE.
DETROIT, MICH.

"When you need TRACTION you need THORNTON"

New 1¼-Lb. "Multi-Vane" Grinder

INGERSOLL-RAND COMPANY has recently added a new "baby" air grinder to its line of pneumatic tools. This tool, called the Size 00, weighs only 1¼ lb. and operates at

Size OO "Multi-Vane" grinder and extra equipment

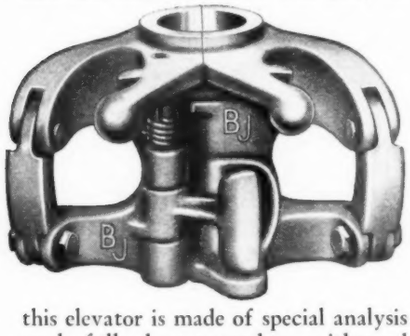
20,000 r.p.m. at 90-lb. pressure. It is built to take 1½-in. diameter organic bonded or 1¼-in. diameter vitrified wheels. Also available are various sizes of collets to take mandrel-mounted grinding wheels or small twist drills.

Although originally intended to be used as a die grinder for tool room and bench work, it is now being used by industry at large for innumerable light grinding jobs wherever metal must be removed from places that would otherwise be hard to reach.

For further details address communications to Ingersoll-Rand Company, 11 Broadway, New York City.

Light Type Center Latch Elevator

BYRON JACKSON Company announces the development of a light Type A center latch drill-pipe elevator for handling collar-type drill pipe and tubing when the working load does not exceed 60 tons. The body of



this elevator is made of special analysis steel, fully heat-treated to withstand the pounding effect of hardened tool joints with a minimum of upsetting. The body is made in halves of practically the same weight, which insures proper balance, and easy opening and closing. The width of the body below the trunnions is held at a minimum to allow more room for the links, to prevent binding, and to permit the lift to be exerted directly under the tool joint or tubing collar with no undue stress on the elevator trunnions.

The operating handles have an underhanging knob at the outer end that provides a safe, easy grip. Stop guards placed toward the rear of the handles prevent the operator from crushing his hands between the handles and links.

The elevator is locked by a patented T-head spring latch that fits into a recess in the body where it cannot accidentally be knocked open when "tailing out." The outer end of the latch is curved as a convenient hand hold when opening the elevator.

The BJ Light Type A Elevator comes equipped with curved link blocks, of new design, which allow free movement of the elevator links when the elevator is being opened or closed. The new type link blocks are hinged at the top, close downwardly, and are securely bolted in place. This design makes a C-link effect when the link blocks are closed, increasing the strength of the elevator trunnions.

Thorough lubrication of the elevator is through a standard grease gun connection in the rear of the elevator.

Complete information about the BJ Light Type A Center Latch Elevator may be obtained from Byron Jackson Company, P. O. Box 2017, Terminal Annex, Los Angeles, California.

OTIS TUBING SERVICE

When the problem of running and pulling pipe under pressure comes up, *Don't Kill Your Well* —call Otis. Otis is a specialist for this special job. The technique and equipment have been developed over a period of ten years—including experience on over 6,000 wells.

Otis maintains regular crews for this work. They are available in every major oil field at a cost that is negligible compared to the damage risk taken in killing your well with mud or water.

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PRESSURE CONTROL, Inc.
DALLAS, TEXAS

Branches: Oklahoma City, Okla.; Houston, Texas; Hobbs, N. M.

Representatives: Otis Eastern Service, Inc., Wellsville, New York; Western Pressure Control, Inc., Los Angeles, California

Export Office: 74 Trinity Place, New York City

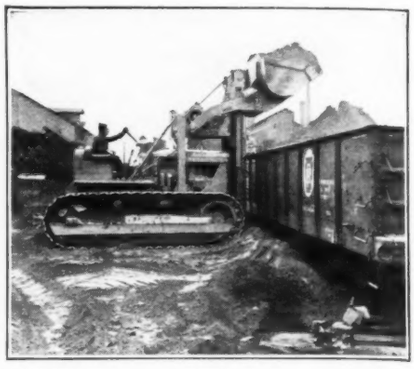
PRESSURE CONTROL - OTIS - SERVICE - EQUIPMENT
"Don't Kill Your Well" Call OTIS

Trackson Announces The Birth of a Giant

THE Trackson Company has announced the addition of a new model to its line of Traxcavators. According to the manufacturer, this new machine is the biggest, most powerful tractor shovel ever built and is known as the Model T 7. It is available with 2 or 2½ cu. yd. bucket and is said to be capable of handling any type of digging, dirt-moving, or material handling with ease, speed, and at low cost. According to Trackson officials, test models were put to the most severe field tests both on the company's proving grounds and on actual projects before the T 7 was approved for production.

Mounted on the "Caterpillar" D 7 Tractor, the T 7 Traxcavator is truly a giant in size and power, yet is said to be low in initial cost, operating costs, and yardage costs. In addition, its versatility and multi-purpose utility make it profitable to use on a wide variety of digging, loading, grading, and dirt-moving operations, not only as a shovel and loader, but also as a scraper, bulldozer, anglegrader, and trail-builder.

The full 23,000-lb. push of the tractor can be applied to the bucket to penetrate and dig the toughest of soils, clay, caliche, shale, or frost. Despite its large size and tremendous power, operators find the T 7 just as fast, mobile



and agile as the smaller Traxcavators, it is said. It travels around the job at speeds to six miles per hour, turns in its own tracks, and has a remarkably fast loading cycle for a machine of its size.

The tractor is equipped with extended track frames and specially fitted to give the T 7 stability and traction to handle a 2½-yd. bucket and get big production on the toughest jobs. Quickly mounted bulldozer blade and other special attachments are available to increase the usefulness of this machine. The big T 7 will be sold and serviced by all "Capterpillar" dealers. For special bulletin on the Model T 7, write to Trackson Company, Milwaukee, Wisconsin.

Tag A.S.T.M. Ramsbottom Carbon Residue Apparatus

TAG A.S.T.M. Ramsbottom Carbon Residue Apparatus may be used for accurately determining the amount of carbon residue left on evaporating in oil under specified conditions. A similar type of apparatus has

been widely used throughout the British empire but has only recently come into common use in this country.

It is intended to replace the Conradson type of carbon residue apparatus as it gives more accurate results that can be duplicated in different laboratories to greater precision, the manufacturer says. The bath is substantially constructed of cast iron and is electrically heated, control being effected

Reilly COAL TAR PRODUCTS

REILLY Pipe Coatings Are TIME-TESTED

• The best laboratory in which protective pipe coatings can be tested is "Mother Earth" herself. No other test can possibly be so positive and assuring—and it is from examinations of pipe, coated with REILLY PRIMER AND PIPE ENAMEL, and installed many years ago, that our claims for these products are made. The ability of REILLY coatings to stand up under various conditions of soil—and under wide extremes of temperature variation; has been amply proved.

Ease and convenience of application and comparative low cost are other considerations which are responsible for the constantly growing preference for these products. Write for literature.

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by a rheostat. The stainless steel coking bulbs into which the samples are placed are heated to a temperature of 1020°F. This temperature may be measured either by an electrical pyrometer or a high temperature glass thermometer made of American heat-resisting glass. The bath liquid is pure lead. Experiments have shown that a molten bath of this type is entirely satisfactory for the application. Such a bath takes up a relatively small space, may be heated rapidly and the temperature controlled conveniently.

This new instrument is illustrated and completely described in a new catalog, No. 699E, being published by C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

Larkin Forged-Steel Tubing Hanger

LARKIN Packer Company, St. Louis, Missouri, has introduced a new forged-steel tubing hanger, developed to provide a safe means of supporting and packing a tubing string in a Berry Pattern Casinghead. The assembly, illustrated herewith, is made up of heavy steel forgings and employs the same slips as used in other Larkin tubingheads.

Besides the employment of forged-steel parts, this new hanger offers numerous other advantages, the manufacturer asserts, as follows:

The top nut has ample tong room, and is threaded 1½ in. long with 8 pitch "Zincoted" straight V threads.

The hanger has split steel ring, ¼ in. thick, between top nut and rubber packing, providing added safety against blowouts, eliminating friction between top nut and packing, and preventing tearing or cutting of the split packing when screwing the top nut.

Two split packing rubbers permit staggering the splits to give a better, pressure-tight seal-off with less weight on the packing, thereby lengthening the useful life of the packing. The packing is installed above the slips so that it may be replaced without disturbing tubing or surface connections. This construction allows the packing effect to be controlled independently of the tubing weight, as none of the tubing weight rests on the packing.

A heavy spring, fitted into a groove around the slips, holds the three segments in alignment to provide a flat surface for the packing and also to prevent cutting or pinching the tubing. Because the slips are 4 in. long, and accurately machined and hardened, they support extremely long tubing strings with a wide margin of safety. Removable slip handles are provided for convenience in landing or adjusting the tubing.

The heavy forged-steel body is available for casing sizes from 5½ in. O.D. through 8⅝ in. O.D. All other parts —slips, packing, steel ring, and top nut —are interchangeable in the various size bodies, and are made to suit either 2-in. or 2½-in. regular or upset tubing.

ENGINEERED

McKissick Traveling Block

To Assure Long Dependable Service with Maximum Safety!

Production men will appreciate the fact that through streamlining, we have designed this block to allow for straight fall and maximum working space in the derrick.

Its features include: Six inch diameter center pin; Extra heavy solid roller bearings; Large bearing surface for extra wear; 30 inch diameter alloy steel sheaves with grooves machined to A. P. I. line size, and heat treated for maximum wear.

It is manufactured with three or four sheaves, with a safe working capacity of 100 and 125 tons respectively. Built by a recognized leader in the manufacture of blocks for oil field use—and backed by years of experience.

McKISSICK PRODUCTS CORP.
TULSA, OKLAHOMA

Brewster Traveling Block For Portable Rigs

BREWSTER engineers have taken into consideration all problems of a portable rig when designing the 3-sheave Model C-60 traveling block.

The concave top is designed to conform with the curve of the crown block sheaves, thus enabling this Brewster "Compact 60" traveling block to be raised to the very maximum height.

Maximum width of side is 27½ in.; maximum width of face, 17¾ in.; overall height, including bail, 42 in.

Sheaves are 26 in. in diameter with flame-hardened grooves ground for A.P.I. line. Exceptional stability is attained by mounting each sheave on double rows of tapered roller bearings. Each set of bearings is individually lubricated through an Alemite fitting in the pin.

The main pin is SAE 4140 heat-treated steel, 5-in. diameter; two becket pins are 1⅜-in. diameter; two bail pins 2¼-in. diameter; SAE 4140 bail 5 in. by 3½ in. at yoke, with 6½-in. opening between block. One-piece side plates are of electric steel, with all bolts and pins countersunk. Space plates between sheaves prevent line pinching and evenly distribute load

on center pin. Capacity is 60 tons. Weight of Model C-60 is approximately 1500 lb.

Further details can be obtained from The Brewster Company, Inc., Shreveport, Louisiana.

On Pipeline Jobs Everywhere

"CLEVELANDS" DO IT -and STICK TO IT!

Aiming always at Perfection, not to "just get by" . . . pioneering sweeping advances in design . . . "CLEVELAND" has raised the level of performance, lowered both initial and upkeep costs of ditching-machines and allied equipment.

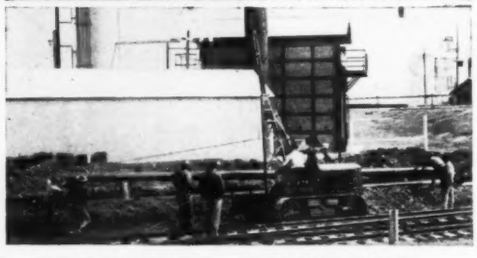
Generous-sized, field-equipped Diesel or Gasoline engines . . . large track area . . . wide tread . . . harder, stronger materials . . . all gears in grease-sealed housings . . . a preponderance of anti-friction bearings . . . "Multi-Speed" transmissions for individual, correct control of all speeds and feeds . . . weight well-balanced on fully-perfected, quick-maneuverable full-crawler mounting . . . quick, easy field servicing due to simple, accessible construction . . . rapid, cheap transportation . . . these are some of the reasons why "CLEVELANDS" are "tops" in real value. Two models illustrated here, "140" Ditcher and "90" Backfiller.

MODEL "140" DITCHER

Digs—16" to 30" wide 5'4" deep, at speeds from ½ foot to 26 feet per minute. Spoil-conveyor shiftable and reversible. Extra strong boom, wheel and buckets. Digs all types of soil successfully. Operates over roughest terrain. Special equipment for stripping pipelines.

MODEL "90" BACKFILLER-PIPE CRANE

A pipeline backfiller that's built to go anywhere. Affords faster cleanup on any size line. Instantly available for lowering slack-loops, pulling road-crossings, unloading or laying pipe.



THE CLEVELAND TRENCHER COMPANY

"Pioneer of the Small Trencher"

20100 ST. CLAIR AVENUE CLEVELAND, OHIO

Thermocouple Checking Furnace

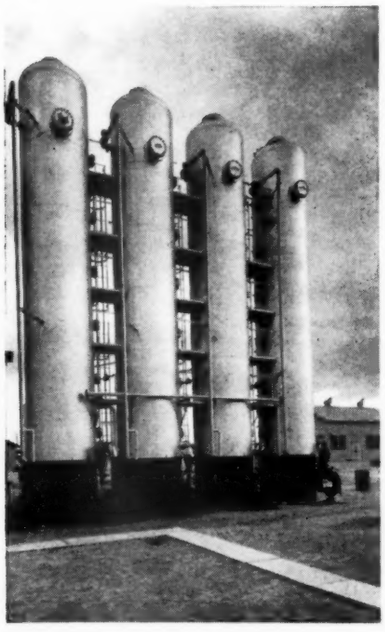
THERMOCOUPLES may be checked to great accuracy and over a wide temperature range in the newly redesigned Leeds & Northrup Checking Furnace. This equipment is a small electric furnace that provides a zone of practically uniform temperature for the intercomparison of laboratory standard couples and for comparison of laboratory standard and plant standard couples.

A new accessory that increases accuracy of checking is a cylindrical copper equalizing block that fits inside the furnace. Drilled into this block are five wells to hold the comparison standard and the four couples being checked. With the equalizing block, checks can be made within ±1°F. from room temperature to 1000°F. Without it, checks can be made within ±3°F. over a range of 300 to 1800°F.

Available with heating elements for either a-c. or d-c. operation on 115 or 230 volts, this furnace requires an input ranging from 40 watts at 300°F. to 1000 watts at 1800°F. When temperature must be increased rapidly, input can be increased to 5000 watts.

For further details, ask Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania, for Catalog E-33A-503.

Wyatt Absorbers



THE absorbers shown here were fabricated by Wyatt Metal and Boiler Works, Houston and Dallas, Texas, for Shamrock Oil and Gas Company, Sunray, Texas, for gasoline plant operation. These towers are 84 in. by 42 ft. and are 400 lb. working pressure.

Midwest Reducing Butt-Welding Elbow

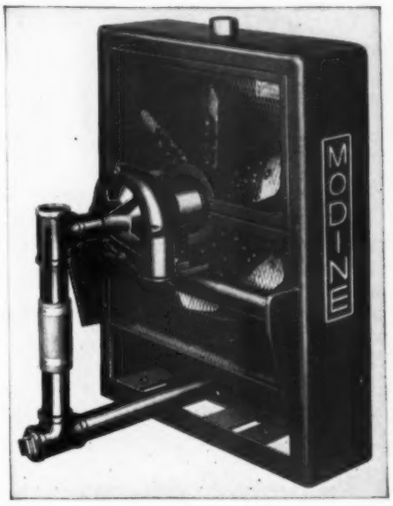
THE reducing butt-welding elbow, illustrated herewith, has recently been developed by Midwest Piping and Supply Company, Inc., 1450 South Second Street, St. Louis, Missouri. In a pipe line when it is necessary to change both direction and pipe size, this reducing elbow will take the place of two welding fittings: (1) a straight elbow

and (2) a straight reducer. The result is a reduction in cost of the welding fittings, elimination of one or two welds, saving in erection time and expense, and improved appearance, according to the manufacturer.

Oil-Field Engine Coolers

A NEW standard line of oil-field pumping engine coolers is announced by the Modine Manufacturing Company, Racine, Wisconsin. Consisting of a radiator, fan, and centrifugal pump built into a sturdy welded steel frame, the coolers are complete, ready to be connected by belt drive to the pumping engine. Replacing the old fashioned cooling tank, Modine units, circulating water at great velocity, inhibit scale and sludge formation in the engine jackets, postponing for many months costly overhaul shutdowns, the manufacturer asserts.

Other advantages include the sectionalized core construction, permitting easy removal of individual sections for cleaning or servicing; the single pulley driving both fan and pump; small size and portability, and the choice of blow-through or draw-through fans.



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PIPE LINE CONTRACTOR

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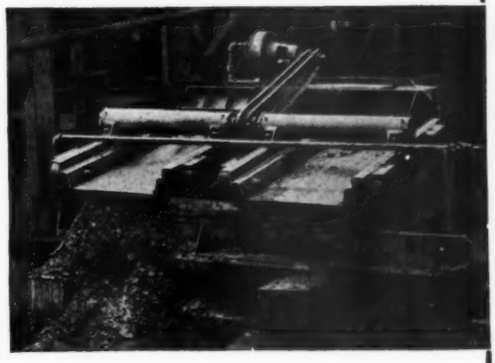
Oil, Gas and Gasoline Lines

5500 Holmes Street Phone H-6938

DALLAS, TEXAS

WORLD'S CHOICE METHOD of RECONDITIONING ROTARY DRILLING MUD



• The Link-Belt mud screen dual hook-up, pictured here in the field and used also as a single unit, is accepted worldwide as the latest and most efficient method of economically reconditioning rotary drilling mud. With its many new and exclusive features this advanced design is a result of Link-Belt's constant research and improvement since introducing the oil field's first vibrating screen more than 10 years ago.

The dual hook-up employs two 24" x 48" screens mounted on skids as one unit, with one mud collecting tank and inlet chute. A single turbine (or motor) drives both screens . . . handling the fluid of today's largest pumps . . . yet the screens operate independently when only one is required. *Write for detailed Folder No. TPE-1872-A.*

LINK-BELT COMPANY Philadelphia, Houston, Dallas, Los Angeles, Kansas City, Mo., New York, Toronto. Sold by most supply houses. 8154A

LINK-BELT MUD SCREEN

EASY TO READ
MARKINGS
THAT ARE DURABLE
CHROME CLAD
THE LUFKIN RULE CO.
LUFKIN
"ANCHOR"
CHROME CLAD
Whether you're working in the bright light of a sunny day or under dim, artificial light, you'll find the new Lufkin Chrome Clad Steel Tapes easy to read. The jet black markings stand out prominently against the satin chrome surface that's unusually free of glare and won't rust, crack, chip or peel—a factor that economy minded men appreciate. The "Anchor" model shown here is in a genuine leather, hand-stitched case. See it at your dealers.
LUFKIN
SAGINAW, MICHIGAN • New York City
TAPES · RULES · PRECISION TOOLS

C.N.G.A. Annual Gadget and Kink Contest

Designated as the "C.N.G.A. Annual Gadget and Kink Contest," the May meeting of the California Natural Gasoline Association will be one of the most novel and interesting in the history of that body, according to L. V. Cassaday, president. The event will be held at the Lebec Hotel on the Ridge Route half-way between Los Angeles and Bakersfield on Friday evening, May 9, with a dinner at 6 o'clock to be followed by the meeting at 7:30 p.m.

All who have developed gadgets used in the natural gasoline industry or who have developed operating kinks used in either office or plant procedure are invited to enter. This invitation is extended to members and non-members alike. There are no entry fees and cash prizes and other valuable awards will be given for winning entries.

The purpose of the meeting is to provide a means of bringing out gadgets and operating kinks where all may view the constructive work of others and where the individual with a gadget may have the opportunity to "get it over." Those concerned about protection of patent rights will find a simplified procedure has been arranged for such protection.

Anyone, excepting company officials, in the natural gasoline, natural gas or allied industries, may enter a gadget or kink; however, gadgets already on the market are not eligible for entry.

Those interested in entering are advised to communicate with George L. Tyler, secretary, C.N.G.A., 510 West 6th Street, Los Angeles, California. An entry blank will be mailed and this should be filled out and returned with a good working drawing or sketch of the gadget or kink.

Prizes will be awarded based on the scoring of five judges who will score on the basis of value, originality, adaptability, facility for constructing, and practicability. The last day to file entries is April 30, 1941.

New Wire Rope Making Machine Has Automatic Features for Precise Control

Under the heading "To Serve You Better," the A. Leschen and Sons Rope Company of St. Louis, Missouri, has announced the installation of a large new wire rope-making machine, which they state is the last word in equipment of its kind. It is also stated that the design of this machine is such that, automatically, there is precise control of every stage in its operation.

Although this new wire rope "closer" is a giant in size, more emphasis is placed on its ability to produce wire rope that will accurately meet definite and predetermined requirements, than on its actual capacity.

The A. Leschen and Sons Rope Company are manufacturers of the well-known "Hercules" (Red Strand) wire rope, which is made in both round strand and flattened strand constructions—in either the Standard or Preformed type. For many years this company has designed most of its wire rope-making machinery, and much of it has been built in its own shops.

General view of wire rope making machine recently installed by A. Leschen and Sons Rope Company. It is equipped with the most up-to-date devices for precision control

Finds Air Travel a Time Saver

Captain A. E. Higgins, vice-president and sales manager of Pittsburgh Equitable Meter Company and Merco Nordstrom Valve Company, saved many hours' traveling time this last winter by flying his new five place Stinson. Only recently he completed a coast-to-coast tour by air to attend the various district sales meetings held by the two companies.

The accompanying picture, taken during Captain Higgins' visit to Columbia, South Carolina, where the southeastern district sales meeting was held, shows W. S. Tomlinson, city engineer, Columbia; Captain A. E. Higgins; Fred Swaffield, Jr., and F. G. Swaffield, district manager.

W. R. Coleman, Secretary-Treasurer of Engineering Laboratories, Inc.

W. R. Coleman, general manager of Engineering Laboratories, Inc., has been made secretary and treasurer of the company.

When Coleman joined the organization in March, 1935, there was a total of 11 employees. Today this employment list numbers 83. The company's rapid growth has, to a great extent, been due to the ability of Coleman in handling the company affairs in the capacity of general manager.

W. R. COLEMAN

A member of the Purchasing Agents Association of Tulsa and Indian Hills Country Club, Coleman before joining the organization was with the Spartan Aircraft Company, and prior to that with the old Prairie Pipe Line Company. He has been closely associated with various phases of the oil and aviation industries since 1927.

F. R. Staley to Magnasol Corporation

F. R. Staley has resigned from the Max B. Miller Company to accept a position as sales and research engineer with the Magnasol Corporation, a division of the Warmer Chemical Company, New York City. He will continue to make his residence in Pittsburgh, Pennsylvania, and call on refiners in Pennsylvania and Mid-Continent areas.

F. R. STALEY

"EVERY BOILER IN THE COUNTRY"

One customer says about SAND-BANUM—the scientific, simple and economical way of removing and preventing boiler scale and corrosion—and we quote—

"We believe every one in the country could use Sand-Banum with the same economy that has been our experience."

"The Entirely Different Boiler and Engine Treatment"

REGARDLESS of your experience with or opinions of boiler scale elimination, we ask that you

Test

SAND-BANUM

on our "Satisfaction or No Money" Guarantee!

AMERICAN SAND-BANUM COMPANY, Inc.

9 Rockefeller Plaza
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Stocks carried by

WESTERN SAND-BANUM COMPANY
Houston, Texas **Fresno, California**
and at other convenient points including leading supply houses

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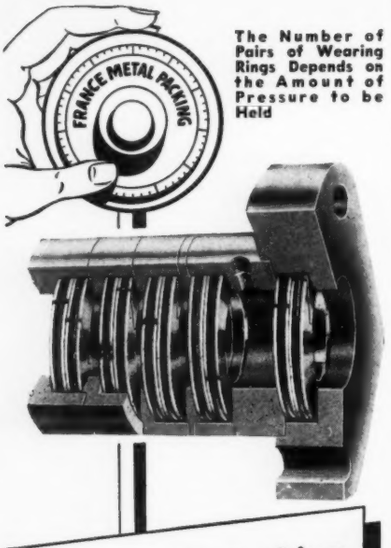
Export Representatives
PETROLEUM MACHINERY CORP.
30 Rockefeller Plaza **New York City**



The Number of Pairs of Wearing Rings Depends on the Amount of Pressure to be Held

The Accurate Packing COMBINATION for High Pressure Jobs

For nearly half a century, France "Full-floating" Metal Packing has proved its stamina, its ability to keep on giving service long beyond a "reasonable expectancy." It is the accurate packing combination (full-floating rings in a metal case) for the efficient sealing of compressor, engine and pump stuffing boxes regardless of pressure, temperature, vapor or gas conditions.

Constructed of few parts, so simple to install, inspect or clean. The type illustrated can be provided with a vent connection in addition to a lubrication connection, if desired.

For longer service and lower operating costs, specify FRANCE, the accurate packing combination that *l-a-s-t-s.*

Sold on approval — Satisfaction Guaranteed

Write for Catalog M-3.

THE FRANCE PACKING COMPANY
Tacony, Philadelphia, Pennsylvania
Mid Continent Representative
MR. J. M. FULLER, 2603 Azle Avenue
Fort Worth, Texas

Original **FRANCE METAL PACKING**

General Johnson Speaks to California Oil Men

Complete and planned coöperation of the oil industry with government, which he believes will forestall seizure and regimentation, was the keynote of an address by Gen. Hugh Johnson at the annual dinner meeting of the California Oil and Gas Association held at the Biltmore Bowl in Los Angeles, April 3. A. L. Weil, toastmaster, presented the two speakers of the evening, the first of which was R. E. Collom, vice-president of Continental Oil Company and president of the association. Collom gave a clear, concise picture of the oil industry in California today and stated that the industry is ready to meet the demands of national defense with an ability to increase throughput of its refineries 80 percent without additional equipment; and that "no one is afraid that we cannot produce enough oil." Well worth careful attention of everyone was his closing remark, "candor and a sense of responsibility to the common cause require me to repeat that the petroleum industry is prepared to meet any national emergency. We are ready to produce anything in our line that is needed, in any quantity and for any use. All we hope is that those who are talking most about the petroleum industry's relation to defense are really thinking of defense and that they let those who know how, and are trained for it, continue to run the oil business."

After pointing out that the oil industry is as much a part of national defense as the army, navy or air force, General Johnson stated his belief that if it is relied upon, confided in, used and encouraged it can be proved to be the very strongest element of American defense in a world aflame. "It needs no regimentation nor government assumption of management—any more now than it did in our former two great crises. Furthermore, it is so excellent an organization, so sternly proved in both peace and war that, in all human experience, it could not be replaced by any theoretical blue-print without paralyzing results and possible national disaster."

If he were in the petroleum industry, said General Johnson, he would be working night and day to see that its coöperation with the government would be so splendid, unfailing, and efficient that seizure and regimentation would be unthinkable. His concrete suggestion was for the oil industry to plan now for some "efficient organization for all-out coöperation by complete concert of action with whatever government group is finally put in responsible and authoritative charge of total American war-production."

Heads Jack Division

Roy P. Williamson has been named sales manager of the Jack Division of The Buda Company, Harvey, Illinois, effective immediately. He was until recently associated with the Gustin-Bacon Manufacturing Company.

New Drilling Company

The Herschbach-McCulloch Drilling Company has been organized with headquarters in the Magnolia Building, Dallas, Texas. Personnel of the firm consists of John L. Herschbach and E. Fred Herschbach, both formerly associated with the Ajax Drilling Company, and J. T. McCulloch, formerly with McCulloch and Ice Drilling Co.

Hercules Establishes Factory Branch at Odessa, Texas

A new oil-field sales and service branch has recently been opened at Odessa, Texas, by Hercules Motors Corporation of Canton, Ohio. Engineering service and complete stocks of gasoline and Diesel engines and power units, as well as replacement parts, will be available at all times at the new location, it is announced. The company also has stores at Houston, and Kilgore, Texas; Salem, Illinois, and Tulsa, Oklahoma.

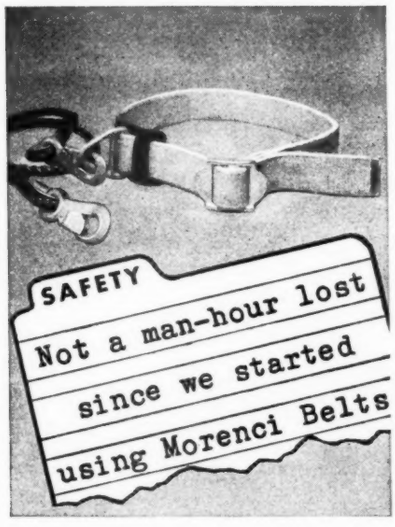
Look for the *Arm and Hammer*

ARMSTRONG BROS.

STUB END WRENCHES

These extra heavy, ruggedly designed Chrome Vanadium Steel Wrenches take long tubular slip-over handles, stand up to long leverage... tighten screws, bolts and nuts far tighter or loosen them even when badly corroded. These are ideal wrenches around rigs, pipe lines and for general heavy duty work. Three types (from 1¼" to 3½") with long hollow tubular steel handles, each of which fits several sizes.

"The Tool Holder People"
331 N. Francisco Ave., Chicago, U. S. A.
Eastern Warehouse and Sales:
199 Lafayette Street New York



Users tell us that the light weight Morenci Safety Belt is so comfortable and easy to adjust that their men not only wear them but *use* them as a matter of habit. It weighs but 25 ounces, complete... yet will outwear and outhold most heavier, less flexible belts. *Continuous* tough strands run the entire length of the belt... unbroken by fastening holes or grommets. Adjustable "D" ring is readily placed in any comfortable position...but once set it *stays put*. Send for Bulletin 4064... it simplifies safety buying. E. D. Bullard Company, 275 Eighth Street, San Francisco, Calif. B-4

Everything BULLARD in Safety

Strube Link-Belt Eastern Division Chief Engineer

Link-Belt Company announces that Harry L. Strube has been appointed chief engineer of the Link-Belt eastern division, with headquarters at the company's Philadelphia plant, to succeed F. F. (Ferd) Waechter, who has resigned after rounding out 43 years of service.

H. L. STRUBE

Strube has been assistant chief engineer at Philadelphia, having begun his Link-Belt service in 1910.

R. P. Green Advanced by Engineering Laboratories

Announcement is made by Engineering Laboratories, Inc., Tulsa, Oklahoma, of the election of R. P. Green, chief engineer, to vice-president and chief engineer.

R. P. GREEN

Green, a registered professional engineer, has been associated with E.L.I. and Seismograph Service Corporation for ten years and he will continue also as chief engineer of the latter company.

TAYLOR FORGE

SPEED

is more vital today than ever before. WeldELLS alone offer you *all* these 8 features — to handle your pipe welding jobs faster, and better.

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General Offices & Works:
Chicago, P. O. Box 485
New York Office: 50 Church St.
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WeldELLS

Seamless Pipe Fittings for Welding

Los Angeles Nomads Induct New Officers

The new officers of the Los Angeles Chapter of Nomads were inducted into office at the regular monthly dinner meeting held in Los Angeles recently. The affair was an open meeting with nearly 80 Nomads and guests present and in addition to the induction ceremonies there were several other important events.

Elmer Decker of Martin-Decker Corporation conducted the induction of the new officers, who are Ernie Fowks of Emsco Derrick and Equipment Company, president; Bill Bettis of M. O. Johnston Oil Field Service Corporation, vice-president; Earl Rees of Oil Well Manufacturing Company, secretary-treasurer; Elmer Smith of Lane-Wells Company, assistant secretary-treasurer; Bob Eiche, sergeant-at-arms, and Roy Hitchcock, deputy sergeant-at-arms.

The charter for the Los Angeles Chapter was presented by Ted Sutter of Baker Oil Tools, Inc., and after the meeting the charter members present signed the parchment. The first honorary membership ever conferred by the Nomads was given to J. E. Brantly of Drilling and Exploration Company for outstanding services rendered to the Nomads by an operator in foreign fields. The presentation of the certificate was by Frosty Martin of Martin-Decker Corporation.

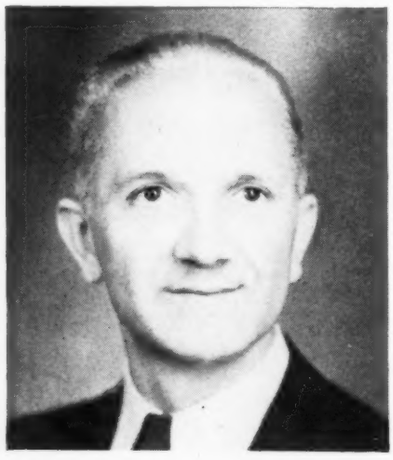
New standing committees were appointed by President Fowks. These were in addition to the executive committee, which consists by constitutional provision of the officers and the immediate past president of the chapter, Ted Sutter. The induction and membership committees were combined and consist of Fred Ripley, chairman; Wallace A. Sawdon, vice-chairman; R. R. Smith, induction master, and Jack Ballagh. The entertainment committee consists of Bob Eiche, chairman; Roy Hitchcock, vice-chairman; Lou Bronzan; George Trembley; Roland Smith; Custer Morrow; Knight Templeton; Tom Murphy, and Waldo Moore. The last five members of the entertainment committee were appointed to assist Eiche in reception duties; the duties of the others will be entirely entertainment.

The speaker of the evening was Louis Chappuis, who has recently been doing geological work in Peru and Brazil for American interests. Being a native of Peru he is acquainted with all parts of that country and gave some interesting data on the life of the country outside the big cities.

Among the guests from foreign fields were Tom J. Downey of Attock Oil Company, Khaur, Punjab, India; A. W. McPherson of Standard Oil Company of California, who was recently in Colombia; Paul B. Sardinha of Drilling and Exploration Company from Bahia, Brazil; Juan A. Castro of the Y.P.F. from Argentina; T. J. M. Sleeman of Caribbean Petroleum Company from Venezuela, and Phil Reed of the Richmond Petroleum Company of Colombia. Also a guest was Ed. Skinner, who is in charge of all foreign operations for the Standard Oil Company of California.

West Virginia Meter School to Meet in August

A. F. Kraus, Chairman for the Fourth Annual Appalachian Gas Measurement Short Course called a meeting of the general committee in Morgantown, West Virginia, recently, for the purpose of making plans and appointing committee members for this year's meeting. It was decided that sessions would be held on the West Virginia campus August 18, 19, and 20, 1941.



A. F. KRAUS

R. O. Borden as chairman of the rules committee presented a revised organization plan for the school that was approved and adopted. Under the new by-laws, an executive committee was created to conduct the affairs of the school during the vacation of the general committee and to appoint the membership of the general committee in accordance with a fixed plan of employment distribution.

The executive committee selected is as follows: Three-year term, G. R. Spindler, West Virginia University, chairman; A. F. Kraus, Peoples Natural Gas Company, and R. W. Hitchman, United Fuel Gas Company; two-year term, Stacy Jones, South Penn Natural Gas Company; J. E. Overbeck, Columbian Engineering Corporation, and Lawrence Hunter, Columbian Carbon Company; one-year term, G. W. Harr, Monongahela West Penn Public Service Company; Joseph M. Low, Hope Natural Gas Company, and T. K. Spalding, Owens-Libbey-Owens Company.

Sub-committees were also appointed to formulate plans and administer the affairs of the 1941 school. These include: Program committee, J. E. Overbeck, Columbian Engineering Corporation, chairman; housing and registration, W. A. Staab, West Virginia University, chairman; banquet and entertainment, A. D. MacLean, Pittsburgh Equitable Meter Company, chairman; exhibits, J. W. Allison, Monongahela West Penn Public Service Company, chairman; publications and merit awards, G. R. Spindler, West Virginia University, chairman; publicity, R. S. Reed, Jr., Pittsburgh Equitable Meter Company, chairman; educational, H. J. Wagner, West Virginia Public Service Commission, chairman; practical methods, C. B. Heist, Manufacturers Light and Heat Company, chairman.

Robinson Chairman A.P.I. Pacific Coast Division

Bruce H. Robinson, General Petroleum Corporation, Los Angeles, California, was elected chairman for 1941-1942 of the Pacific Coast District of the American Petroleum Institute's Division of Production at the district's recent spring meeting. E. L. Davis, The Texas Company, Los Angeles, was elected vice-chairman for the Los Angeles Basin; R. W. Borden, Barnsdall Oil Company, Elwood, California, for the Coastal District, and Paul E. Lehr, Shell Oil Company, Inc., Bakersfield, California, for the San Joaquin Valley. W. G. Corey, Pacific Gear and Tool Works, Los Angeles, is treasurer, and D. S. Kilgour, California Oil and Gas Association, Los Angeles, is secretary. R. N. McMaster, Chanslor-Canfield Midway Oil Company, Los Angeles, was elected chairman of the district advisory committee.

BRUCE H. ROBINSON

L. A. Estes New President South Chester Tube

L. A. Estes has been elected president of South Chester Tube Company, succeeding the late Gustavus W. Cook.

L. A. ESTES

Estes was formerly executive vice-president.

John W. Lawton, continuing as secretary, has also been elected treasurer, succeeding Francis J. Tucker, who is joining the sales department as special representative.

A.P.I. Panhandle Chapter Meets

The regular monthly meeting of the Panhandle Chapter of the American Petroleum Institute was held at Pampa, Texas, April 8. Headlining the program was a paper and moving picture slide illustrations entitled "The Purpose and Accomplishments of Boiler and Machine Inspection," presented by J. L. Frye, chief inspector for the Hartford Steam Boiler and Insurance Company of Denver, Colorado.

Another interesting paper was presented by Clarence Glasgow, chief engineer for the National Tank Company, Tulsa, Oklahoma, dealing with the efficiency and benefits derived by using small circulating heaters for treating oil in settling tanks.

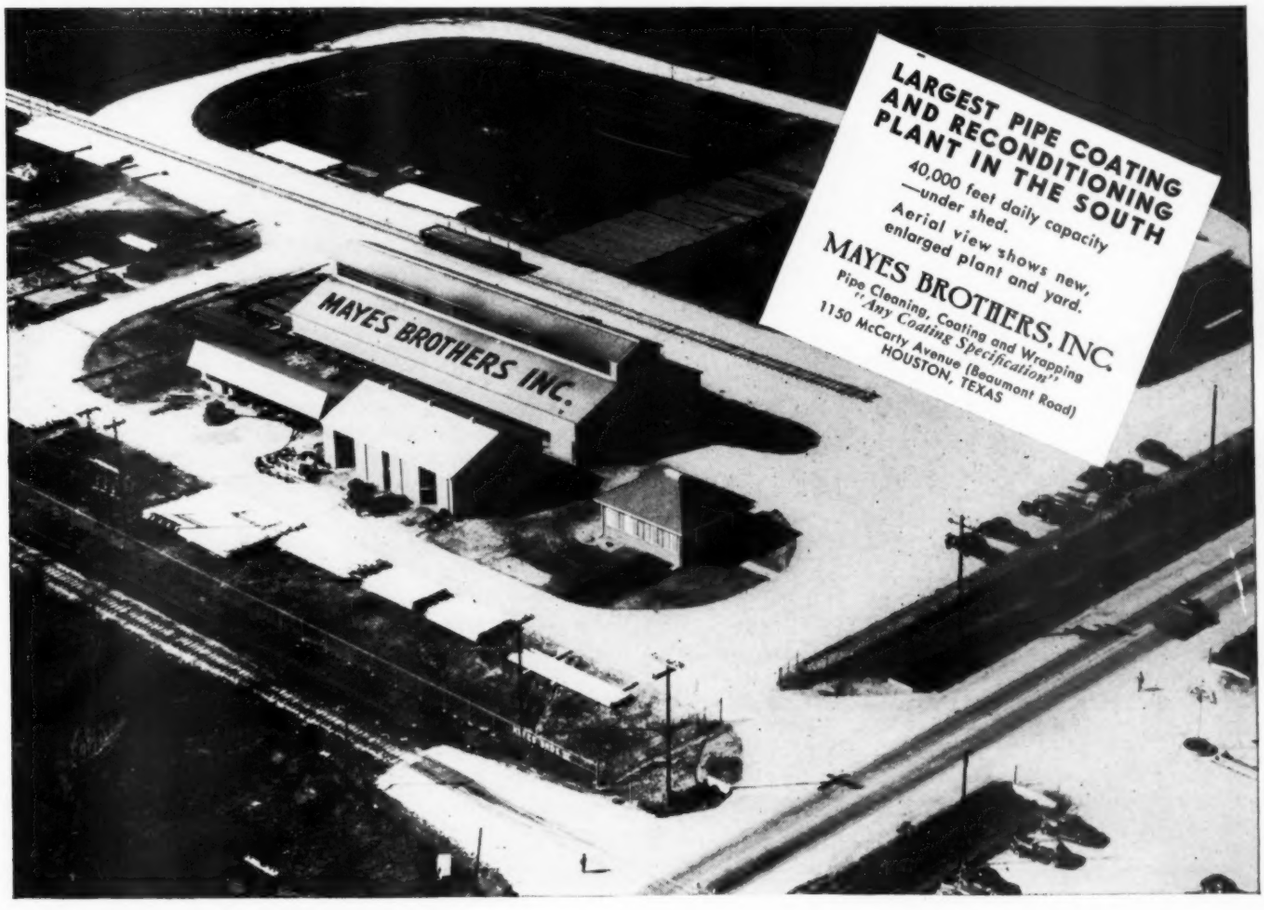
A delightful 20 minutes' entertainment was supplied by Bill Haley's accordion and marimba band sponsored by Tarpleys Music Store.

Lane-Wells Opens Branch at Hawkins, Texas

Lane-Wells Company, technical oil field services, has opened a truck station at Hawkins, Texas, according to Morton T. Higgs, Gulf Coast division manager. L. A. Gratehouse is the operator in charge. The address is Cobbs Garage, Hawkins, Texas.

E. P. Hays Chairman A.P.I. Southwestern District

E. P. Hayes, The Texas Company, Houston, Texas, was elected chairman for 1941-1942 of the Southwestern District of the American Petroleum Institute's Division of Production at the district's recent spring meeting. Vice-presidents, elected to represent various sections in the district, are: S. E. Buckley, Humble Oil and Refining Company, Houston; W. H. Collins, Shell Oil Company, Inc., Wichita Falls, Texas; D. A. Jordan, The Atlantic Refining Company, Odessa, Texas; E. B. Miller, Jr., Tide Water Associated Oil Company, Kilgore, Texas; Maston Nixon, Southern Minerals Company, Corpus Christi, Texas; J. H. Rambin, The Texas Company, New Orleans, and John D. Trimble, Bailey and Trimble, El Dorado, Arkansas. R. H. McLemore, Sun Oil Company, Dallas, Texas, is secretary-treasurer. L. A. Ogden, The Pure Oil Company, Fort Worth, Texas, was elected chairman of the district's advisory committee.

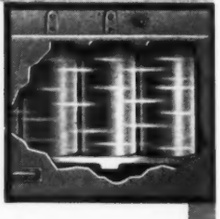

MAYES BROTHERS INC.
LARGEST PIPE COATING AND RECONDITIONING PLANT IN THE SOUTH
40,000 feet daily capacity —under shed.
Aerial view shows new, enlarged plant and yard.
MAYES BROTHERS, INC.
Pipe Cleaning, Coating and Wrapping "Any Coating Specification"
1150 McCarty Avenue (Beaumont Road)
HOUSTON, TEXAS

Lower
FUEL CONSUMPTION

Red Seal Engines
alone offer all these
Improvements . . .

- INDIVIDUAL PORTING
- 100% COUNTERBALANCED CRANKSHAFT
- PRESSURE LUBRICATED VALVE TAPPETS

with
Continental's
FULL LENGTH
WATER JACKET



Bottom portions of these full length jackets have a natural thermo-circulation. Upper portions are cooled by Continental's packless, ball bearing centrifugal pump. This pump discharges large quantities of water into a distributing tube located under valves. From this tube the cooling water is constantly sprayed onto each valve seat and circulates around the top of each cylinder bore. There are no hot spots. There is no heat distortion. Continental Red Seal Power hits a new high in smooth, balanced performance.

ORIENTAL TRANSMISSION AND PACKING CO.
2612-14 COMMERCE ST. DALLAS, TEXAS

Continental Motors Corporation
MUSKEGON, MICHIGAN

TRADE LITERATURE

What to Write For

REPUBLIC STEEL CORPORATION, Cleveland, Ohio, is offering descriptive literature giving recommended setting depths for the various grades of Republic Electric Weld Casing.

Bulletin 601 is available from THE MARLEY COMPANY, FAIRFAX AND MARLEY ROADS, Kansas City, Kansas, giving facts and figures on numerous Marley installations now operating in every service where water-cooling equipment is used. The data are based on recent surveys of Marley cooling tower performance.

The new "TOLEDO" catalog, published by The Toledo Pipe Threading Machine Company, Toledo, Ohio, describes the company's pipe-cutting and threading equipment, and will be sent free upon request.

THE LINK-BELT mud screen is fully discussed in folder No. TPE-1872-A, and can be obtained from Link-Belt Company, Philadelphia, Houston, Dallas, Los Angeles, Kansas City, New York, and Toronto.

BETHLEHEM STEEL COMPANY, Bethlehem, Pennsylvania, has recently published a catalog giving information about Bethlehem steels available for high-temperature service. A copy will be sent free upon request.

OAKITE PRODUCTS, INC., 48 Thames Street, New York, New York, will send upon request complete details on the cleaning of oil-field equipment.

E. M. SMITH COMPANY, 600-650 South Clarence Street, Los Angeles, California, is mailing to interested parties Bulletin No. 21-OF, which gives detailed information on Grizzly "Hug-Tite" drill-pipe protectors and stabilizers.

CATALOG GP-4, issued by the Coffing Hoist Company, Danville, Illinois, describes and illustrates ratchet lever, spur gear, and electric hoists.

J. H. WILLIAMS AND COMPANY, 225 Lafayette Street, New York, New York, is mailing booklet A-431 to those writing the company for a copy. The booklet describes the Williams' "C" clamp for shop and industrial requirements.

ELASTIC STOP NUT CORPORATION, 2324A Vauxhall Road, Union, New Jersey, has available free a 56-page catalog and data book explaining the Elastic Stop principle. The catalog also presents test and application data and lists the complete line of nuts.

BULLETIN NO. 130 and the C-F CATALOG, published by The Chaplin-Fulton Manufacturing Company, 28-40 Penn Avenue, Pittsburgh, Pennsylvania, discuss pressure control. Copies will be sent free upon request.

Those interested in purchasing safety equipment should write for BULLETIN 4064 from E. D. Bullard Company, 275 Eighth Street, San Francisco, California.

"Valuable Facts About the Use and Care of Wire Rope" (Form-6162) is a 50-page booklet giving helpful information and suggestions for the proper handling and maintenance of wire rope. It covers such important subjects as unreeling and uncoiling, seizings, attaching of clips and sockets, splicings, lubrication, gauging, etc. Copies may be obtained by writing the American Steel and Wire Company, Rockefeller Building, Cleveland, Ohio.

The new 1941 edition of the JOHNS-MANVILLE INDUSTRIAL PRODUCTS CATALOG is now available. This 52-page, illustrated book contains a wealth of information and recommendations on high and low temperature insulations for every industrial need from 400°F. below zero to 2500°F. above.

Copies of this book, Form GI-6A, are available upon request to Johns-Manville, 22 East 40th Street, New York City.

ALLIS-CHALMERS MANUFACTURING COMPANY, Milwaukee, Wisconsin, has issued a new leaflet, B-6153, on their complete self-contained engine-driven pumping units for service entirely independent of any outside source of power supply.

Typical uses for Homestead Valves in the defense industries are shown in a 4-page folder titled, "Physically fit to shoulder *Their* jobs for National Defense." Copies will be sent to interested parties. Address Homestead Valve Manufacturing Company, Inc., Coraopolis, Pennsylvania.

An interesting pamphlet entitled "FIELD APPLICATION OF TOOL JOINTS" has been issued by Reed Roller Bit Company, P.O. Box 2119, Houston, Texas. This publication, Bulletin 411-T, will be mailed free upon request.

Alco Products Division of American Locomotive Company, 30 Church Street, New York, New York, has issued three pamphlets:

BULLETIN NO. 1024—Feed water heaters for high-pressure power plant service .

BULLETIN NO. 1022—Pre-fabricated piping.

BULLETIN NO. 1025—Heat exchangers, liquid-to-liquid for oil refinery and gasoline plant service.

Frick-Reid Opens Store

Frick-Reid Supply Corporation announces the opening of a new store at Sandyville, West Virginia, to serve the Oriskany sand area. Morgan Wilkins has been appointed store manager. F. M. Fisher is district sales manager at Pittsburgh, Pennsylvania.

Ohio Oil to Install New Unit

The Ohio Oil Company has signed a license agreement with Universal Oil Products Company and is installing a U.O.P. non-selective catalytic polymerization unit at its refinery at Robinson, Illinois.

The unit was designed by Universal engineers and is being built by the Ohio Oil Company. The charge for the unit will be the higher olefins produced in cracking by four Holmes-Manley units and one Kellogg unit.

New stabilization equipment is being installed to stabilize the cracked gasoline and prepare the charge for the poly unit.

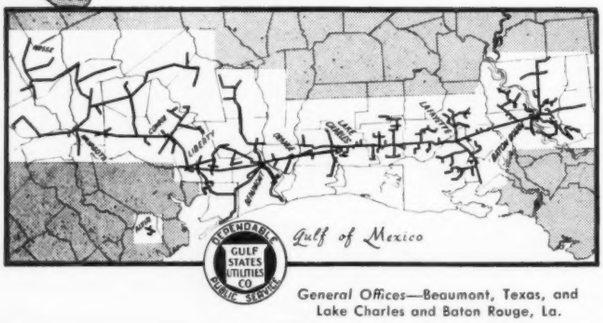
R. E. Luton is superintendent of refineries, and R. W. S. Musgrave, chief engineer.

There's a type of Williams' "C" Clamp for every shop and industrial requirement whether for heavy, medium or light service. All Williams' "C" Clamps are drop-forged and heat-treated to Williams' exacting specifications. They assure you the utmost in dependable performance and long life. Full range of sizes from ¾ to 18″ gap. Ask your supplier or write for booklet A-431 describing these fully guaranteed tools.

J. H. WILLIAMS & CO.
225 Lafayette St., New York, N. Y.

READY TO SERVE

Plenty of Reserve



General Offices—Beaumont, Texas, and Lake Charles and Baton Rouge, La.

Keeps Discharge Constant—Full-Speed Operation Safe

COMPRESSOR REGULATOR

As a close regulator of pressure on constant-speed pumps, the C-F Compressor Regulator has no equal. Thoroughly dependable in all applications where such a device is needed. Excess discharge pressure flows through and is relieved with no appreciable variation in the suction line. Lever-type regulator is here shown. Spring-loaded type is equally sure-working. Ask for Bulletin No. 130, also C-F Catalog covering all needs of pressure control.

The CHAPLIN-FULTON MFG. CO.

28-40 PENN AVE. CF PITTSBURGH, PA.

Book Reviews

Sabotage—How to Guard Against It, by Harry Desmond Farren. Published by National Foremen's Institute, Inc., Deep River, Connecticut (1940), 56 pp. Price, $1.00.

This timely discussion should be of real interest to every American who is concerned with the menace of Fifth Column activities and other attempts to interfere with the Defense program.

Actual cases of sabotage are cited and general suggestions are given for guarding against inadvertently giving vital information to enemies of the nation.

●

Geophysical Prospecting for Oil, by L. L. Nettleton. Published by McGraw-Hill Book Company, Inc., New York, New York (1940), 427 pp. Price, $5.00.

Intended for the student or lay reader rather than the geophysical specialist, the book does, nevertheless, present a fairly advanced and exhaustive treatment of each of the four major geophysical prospecting methods.

As written, the book is the outgrowth of a series of lectures given by the author at the University of Pittsburgh, principally for students in petroleum geology and petroleum engineering. Consequently it is designed for those having a geological rather than a physical background. Physical fundamentals have been emphasized, however.

●

Crosby-Fiske-Forster Handbook of Fire Protection, Ninth Edition, by Robert S. Moulton, General Editor. Published by National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts; 1218 pp. Price, $4.50 postpaid.

The new edition of this authoritative handbook is complete and thoroughly up-to-date, and well worthy of the reputation that past editions have earned of being the standard work in its field.

Examples of sections of the handbook that are of particular interest to oil men are those chapters dealing with heating appliances, flammable liquids, gases and internal-combustion engines, hazardous chemicals and explosives, special extinguishing systems, and the many chapters dealing with public and private fire protection.

Most of these chapters have undergone extensive changes since the last edition, proving conclusively that the science of fire protection has been taking rapid strides forward during the last five years.

●

Geophysical Exploration, by C. A. Heiland. Published by Prentice-Hall, Inc., New York, New York (1940), 963 pp. Price, $10.00.

The author has endeavored to present the material pertaining to geophysical methods so that the relations, differences, common features, and, particularly, the fundamentals would be clearly understood. Divided into two parts, the first is written in non-technical language for those who desire a superficial knowledge of the working principles of geophysical practice. The second and major portion is written for the technical student of geophysics.

Geophysical methods are classified broadly as: major and minor. The four major methods are: gravitational, magnetic, seismic, and electrical. Classed as minor, are those methods utilizing elastic properties, as in submarine, airplane, or iceberg detection; those utilizing thermal effects, as in geothermal logs of oil wells; gas detection, and measurement of radioactivity.

"Jack" Walton Made Sales Manager Unit Rig

Unit Rig and Equipment Company, Tulsa, Oklahoma, has announced the appointment of George W. "Jack" Walton as sales manager. Walton recently resigned as vice-president and sales manager of the Emsco Derrick and Equipment Company, after having been connected with that organization for a period of 15 years.

GEORGE W. "JACK" WALTON

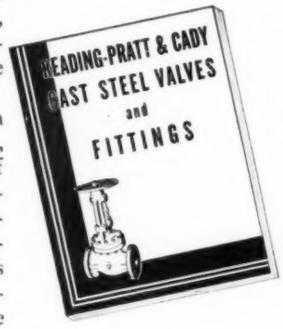
Prior to his connection with Emsco, Walton was connected with Wilson-Snyder, and previous to that he served five years with the National Supply Company, two years of which were spent in Europe with headquarters in London. It is interesting to know that Walton has also handled export sales for Emsco and will pay particular attention to the export market for Unit Rigs. He is a member of the Los Angeles Chapter of Nomads.

Walton is a native Texan and received his early education there, but later attended the Missouri School of Mines. With Mrs. Walton, he will immediately establish his residence in Tulsa.

Reading-Pratt and Cady New Steel Valve Catalog

Men who are responsible for the specification and application of cast-steel valves and cast-steel fittings will welcome the new catalog No. 332 just published by Reading-Pratt and Cady Division of American Chain and Cable Company, Inc.

Made up in the convenient filing size of 11 in. by 8½ in., with concealed wire binding so that sheets lie conveniently flat, it contains a wealth of useful information presented in a concise but complete manner.



It is profusely illustrated with outside and cross-sectional views, as well as views of a number of individual valve parts. Interesting photos of the design, materials testing and research activities are followed by pictures of key operations in the manufacturing departments of the plant at Reading, Pennsylvania.

The next section gives a complete explanation of the markings of cast-steel valves and fittings and standard symbols. The typical chemical compositions and physical properties of Reading-Pratt and Cady metals are given in the pages devoted to material specifications.

Design features of the various types of valves are clearly shown by means of illustrations of parts.

The main body of the catalog is arranged so that each two-page spread shows exterior and cut-away views, with dimensional drawings and complete specifications for a particular type of valve of a given pressure rating.

Cast-steel fittings are covered in a series of pages that show dimensional line drawings and specification tables.

Engineering data applying to the selection and installation of cast-steel valves and fittings are covered in a special section.

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as the number one handy tool for all types of maintenance and construction work. "Safety-Pull" ratchet lever hoists are the safest and fastest hoists built because they are the only hoists equipped with a dual ratchet and pawl assembly, independent of each other, and the load is always under control. There is no clutch to slip and hoist will not drop its load.

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"TOLEDO"

Frank Chase, Retired Gas Official, Dies

Frank L. Chase, retired vice-president of the Lone Star Gas Company, Dallas, Texas, died early this month as a result of a fall suffered in a Florida hotel where he and Mrs. Chase had been spending their vacation. He died on a train near Memphis, Tennessee, while en route to Dallas.

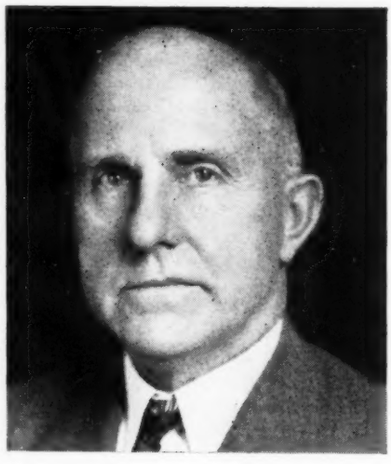
FRANK L. CHASE

An official of the Lone Star Gas Company for 22 years, Chase retired in June, 1939.

During his years, Chase had rendered extensive service in the gas and allied industries, and in May of last year was honored as the grand old man of the natural gasoline division of the International Petroleum Exposition at Tulsa, Oklahoma. Other honors were appointment to a federal commission, designated as the advisory board of the United States Bureau of Mines in 1935, and in 1939 his appointment as a member of the American Petroleum Institute's central committee on measuring, sampling, and testing natural gas and gasoline.

Egan Heads Bridgeport After Death of Buschow

M. J. Egan has been advanced to the position of vice-president and general manager of Bridgeport Machine Company, Wichita, Kansas, to succeed as active head of the company A. A. Buschow, who died March 17. Egan began his oil career as a tool dresser in the old cable-tool days, spending a number of years as a cable-tool driller in Mid-Continent fields. He went with Bridgeport 18 years ago as a blacksmith's helper in the manufacturing division. After a short time, he was transferred to the cost accounting department of the general offices, from which position he progressed through the various departments to the office of comptroller and office manager. In this position he has been active in the management of the company for a number of years.



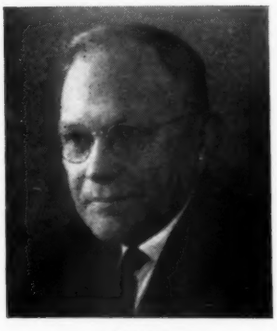
A. A. BUSCHOW

The death of Buschow, who was president and general manager of Bridgeport, followed a gall bladder operation. He had headed the company 15 years and had been associated with the organization for 20 years. Previously he has been in the banking business in Kansas and Colorado. He was widely known in business circles throughout the midwest, and in addition to being the largest stockholder in the Bridgeport Machine Company, was a large-scale independent oil operator.

New Officers A.A.P.G.

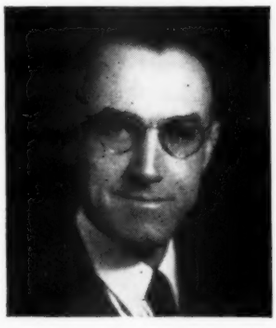
Ed W. Owen, San Antonio, Texas, was elected president of the American Association of Petroleum Geologists for the coming year at the society's annual convention in Houston this month. Other officers elected are: Earl B. Noble, Los Angeles, California, vice-president; Edmond O. Markham, secretary-treasurer. Walter A. Ver Wiebe, Wichita, Kansas, was re-elected editor of the Bulletin. J. P. D. Hull is business manager of the association. L. S. Snider is past-president.

ED W. OWEN



L. C. SNIDER

EDMOND O. MARKHAM



J. P. D. HULL

W. A. VER WIEBE

Conry Retired by Carter

J. J. Conry, president, The Carter Oil Company, Tulsa, Oklahoma, retires effective April 30. L. F. McCollum, executive vice-president and manager of the exploration department of the company, will succeed him. O. C. Schorp, vice-president and manager of the production department, becomes executive vice-president.

J. R. McWilliams, of Shreveport, Louisiana, president of the Louark Producing Company, will go to Tulsa as a director and manager of the production department. Louark Producing Company and Carter Oil Company, both subsidiaries of Standard, are being merged.

Harold F. Moses, chief geologist, in addition to retaining that post, will be manager of the exploration department. Condon MacKay, manager of the land division of the exploration department, becomes assistant manager of the exploration department. William A. Watkins, eastern division superintendent at Mattoon, Illinois, becomes southern division superintendent at Shreveport. Ralph E. Damp will succeed Watkins.

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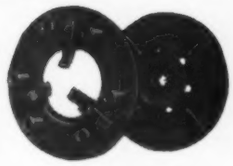

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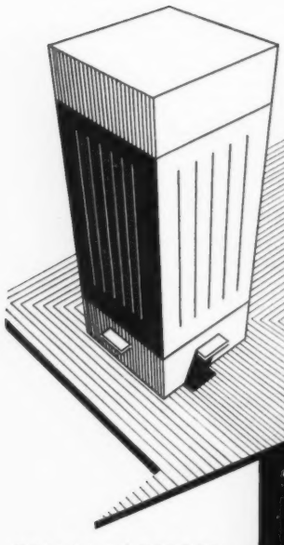

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Ihrig Appointed District Manager for Kobe

The appointment of H. K. Ihrig as Illinois district manager has been announced by Kobe, Incorporated, manufacturers of the Kobe hydraulic pumping system and Kobe screen pipe.

H. K. IHRIG

Ihrig will make his headquarters in the company's new offices at Mount Vernon and brings to his position a well-rounded experience with the Kobe System, having been previously associated with the company's technical service work in both Kansas and Oklahoma City and more recently having been Kobe's district representative in Tulsa.

After attending school at the Missouri School of Mines and the Oklahoma A. and M. School of Engineering, Ihrig became associated with the petroleum engineering work of the Wilcox Oil and Gas Company, later joining the same department of the Phillips Petroleum Company at Oklahoma City.

In 1936 he joined the editorial staff of one of the oil-country trade papers and there became interested in the development of special equipment for treating crude oils.

The appointment of Ihrig as Illinois district manager is part of an expansion program being effected by Kobe, Incorporated.

Pittsburgh Equitable Acquires National Meter Company

Pittsburgh Equitable Meter Company of Pittsburgh, Pennsylvania, has purchased the assets of National Meter Company of Brooklyn, New York, thereby bringing together, under one management, the facilities of two of the country's oldest meter manufacturers. The National Meter Company's plant will be operated as a division of the Pittsburgh Equitable Meter Company.

Both President W. F. Rockwell of the Pittsburgh Equittable Meter Company, and President N. J. Kenny of National, have emphasized the completeness of the line of meters that this purchase makes possible. Every commercially manufactured type of liquid meter is now represented in the complete Pittsburgh-National line, it is stated.

Of interest is the fact that there is no overlapping between Pittsburgh products and those made by National. Structural differences and design features in meters identified by trade names, and popularized during the many years of separate operation, will be continued as the Pittsburgh-National line.

The National Meter Company was founded in 1870 by John C. Kelley. Associated with Kelley from the beginning was Dr. Lewis H. Nash, the noted inventor, to whom was granted 92 patents on liquid meters. For the last 71 years this firm has been manufacturing high quality meters exclusively. Trade names of National meters familiar to the petroleum industry include Empire, Crown, Nash, and Gem.

The Pittsburgh Equitable Meter Company was originally founded as the Pittsburgh Meter Company in 1887 by the inventive genius, the late George Westinghouse. During these many years of successful operation there have been developed such well-known meters as the Pittsburgh Piston, the Pittsburgh Rotary, the Pittsburgh Rotocycle, the Pittsburgh Disc, and the Pittsburgh Grease.

MEETINGS

Petroleum Industry Electrical Association—April 23, 24, and 25, Tulsa, Oklahoma.

Natural Gasoline Association of America, Annual Meeting—April 23, 24, and 25, Baker Hotel, Dallas, Texas.

National Petroleum Association—April 24 and 25, Semi-annual Meeting, Hotel Cleveland, Cleveland, Ohio.

Petroleum and Natural Gas Conference—April 25 and 26, State College, Pennsylvania.

Liquefied Petroleum Gas Association, Inc., Southern Section—April 28 and 29, Roosevelt Hotel, New Orleans, Louisiana.

California Natural Gasoline Association, Monthly Meeting—May 1, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

American Gas Association, Natural Gas Section—May 5, 6, 7, and 8, Dallas, Texas.

Society of Automotive Engineers, National Production Meeting—May 12 and 13, Schroeder Hotel, Milwaukee, Wisconsin.

American Institute of Chemical Engineers—May 19, 20, and 21, Chicago, Illinois.

American Petroleum Institute, 11th Mid-year Meeting—May 19, 20, 21, 22, and 23, Mayo Hotel, Tulsa, Oklahoma.

National Association of Purchasing Agents (Oil Company Buyer's Group)—May 26, 27, 28, and 29, Stevens Hotel, Chicago, Illinois.

Society of Automotive Engineers, Summer Meeting—June 1, 2, 3, 4, 5, and 6, The Greenbrier, White Sulphur Springs, West Virginia.

Illinois-Indiana Petroleum Association, Ninth Annual Petroleum Conference—June 7, Robinson, Illinois.

Liquefied Petroleum Gas Association, Inc., Pacific Coast Section—June 9 and 10, Fairmont Hotel, San Francisco, California.

American Society of Mechanical Engineers, Petroleum Division, Annual Meeting—June 16, 17, 18, 19, and 20, Kansas City, Missouri.

Pennsylvania Grade Crude Oil Association, Annual Meeting—June 19 and 20, Bradford, Pennsylvania.

Kentucky Oil and Gas Association, Mid-Year Meeting—June 20 and 21, Lexington, Kentucky.

Annual Society for Testing Materials—June 23, 24, 25, 26, and 27, 44th Annual Meeting, Palmer House, Chicago, Illinois.

American Chemical Society—September 8, 9, 10, 11, and 12, Atlantic City, New Jersey.

National Petroleum Association, Annual Meeting—September 17, 18, and 19, Hotel Traymore, Atlantic City, New Jersey.

Texas Mid-Continent Oil and Gas Association, Annual Meeting—October 9, 10, and 11, Beaumont, Texas.

California Natural Gasoline Association—October 31, Los Angeles, California.

American Petroleum Institute, 22nd Annual Meeting—November 3, 4, 5, 6, and 7, San Francisco, California.

American Association of Petroleum Geologists—November 6 and 7, Los Angeles, California.

International Petroleum Exposition—May 16, 17, 18, 19, 20, 21, 22, and 23, 1942, Tulsa, Oklahoma.

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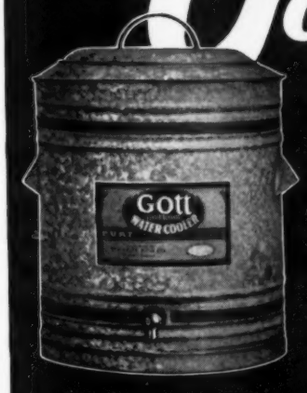

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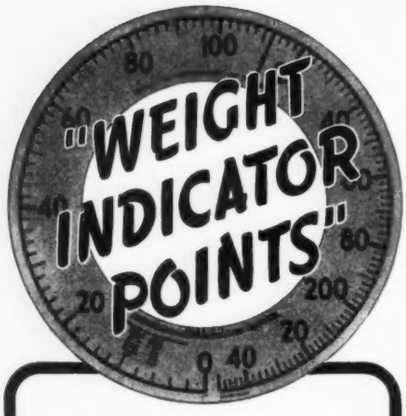

It's an old Martin-Decker custom to give the customer what he wants . . . but at the same time Martin-Decker wants the customer to have the instrument *best suited to his job.*

Take Tool Pusher Model Weight Indicators and Unitized Mud Pump Gauges, for example. These instruments are fine for some jobs. But as drilling problems become more complex, such instruments — located at great distances from the driller — cannot be expected to provide the information needed to meet these problems effectively.

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REGULAR INSPECTION SAVES WIRE ROPE DOLLARS

No. 7 in a series of informative articles for wire rope users, prepared by the Macwhyte Wire Rope Company. Previous articles in series available on request on your company letterheads.

It Pays PLENTY to Inspect Your Wire Rope REGULARLY

Don't wait until a failure occurs before examining your wire ropes. Look them over at regular intervals.

Close examination will not only indicate when it's time to put on a new rope but it will also reveal many things about the way your rope likes its work—whether it is suited to the job.

For instance—wires breaking without showing wear indicate excessive bending—sheave and drums are too small or rope construction is too coarse.

Rope crushing or flattening indicates too much pressure—improper winding—or rope not constructed to withstand the condition.

Whole strands or entire rope breaking soon after installation means overloading . . . or indicates the need for a stronger or larger diameter rope. INSPECT YOUR ROPES REGULARLY and you will become familiar with the behavior of your wire rope. This will enable you to detect many enemies you can correct to your own satisfaction and savings in Rope Cost.

If your ropes are not adapted to the work they are doing and the reason is not apparent—call in your Macwhyte wire rope representative or consult the manufacturer of your equipment.

REMEMBER — Macwhyte is ready to help you whenever you call. Men at Macwhyte who *make* "The CORRECT rope for your equipment" and study it on the job, know how to get the most out of a rope. They'll gladly give you the benefit of their experience.

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Manufacturers of rope wire—braided wire rope slings—Monel Metal and Stainless Steel wire rope—aircraft cable, tie-rods, and "Safe-Lock" terminals for aircraft—and wire ropes for all requirements.

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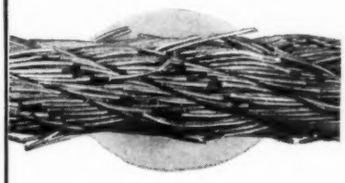
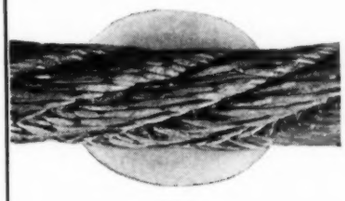
Are these common causes for wire rope failure costing you money?



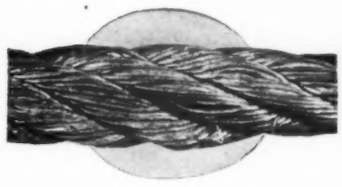
1. Sheaves too small. This rope was forced to travel continuously over sheaves whose diameters were too small. This caused severe bending fatigue. Result—broken wires, ruined rope. (Note: PRE formed rope would have lasted much longer in this case.)

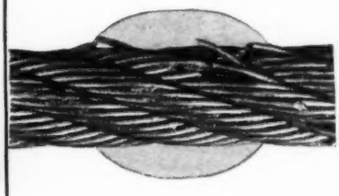
2. Drum abrasion and abuse caused this. The rope was scuffed over and over against previous wraps on a flat-faced drum. Its life ended long before it should have.



3. Kinking caused this. The dog-leg, or kink, was finally straightened out of this rope . . . but notice the uneven wear at the point where the kink had been. Beware of dog-legs! They're expensive.

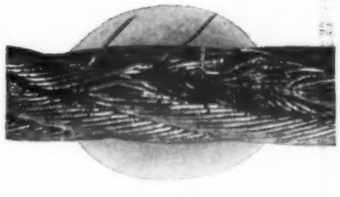
4. Uneven drum winding is a frequent rope-wrecker. This rope was wound unevenly time after time on to a drum. Result—it is crushed and flattened. The service cost of this rope was unnecessarily high. WATCH how the rope winds!





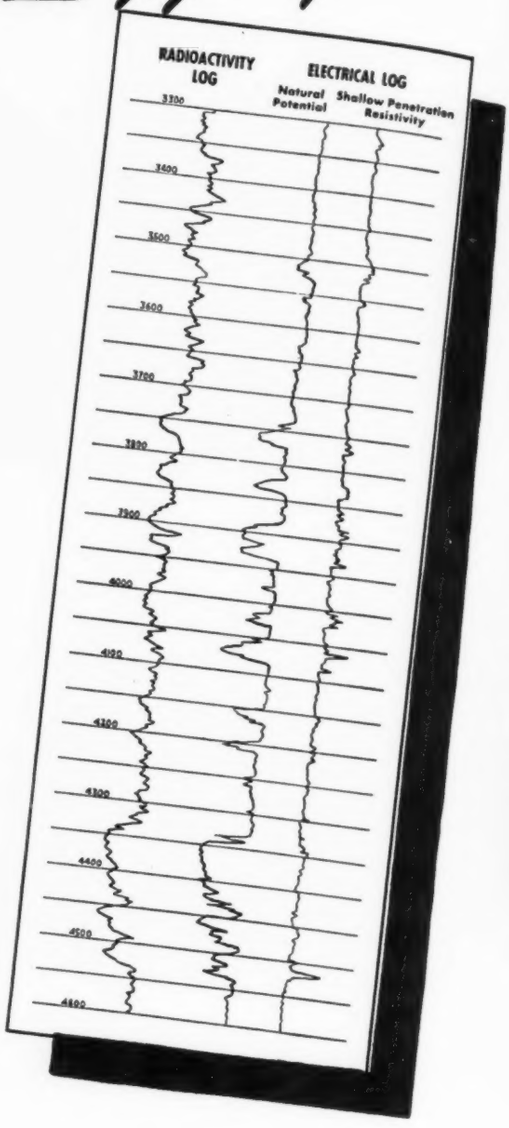
5. Acids Did This. This rope was attacked by high Sulphur content in the water and crude oil through which the rope operated. A heavily internally lubricated rope will resist the action for a time.

6. Foul Play "killed" this rope. While in operation, this rope met with an accident that mashed and cut many of its wires. Result—a ruined rope, and many a rope dollar wasted that could have been saved.



The Petroleum Engineer, published monthly August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, seventh floor Allen Building, Dallas, Texas. Subscription price, $2.00 per year, $3.00 for 2 years, 25c a copy. Entered as second-class mail matter May 1, 1932, at the post office at Dallas, Texas, under the act of March 3, 1879.

Radioactivity Well Logging



GIVES YOU ACCURATE INFORMATION ON FORMATION CHARACTERISTICS IN CASED OR OPEN HOLE . . . . .

RADIOACTIVITY LOG USES:

1. ***Locating the structural position of all possible pay zones in oil wells.***
2. ***Correcting the structural position of productive zones.***
3. ***Obtaining accurate cross sections and correlations of old pools.***
4. ***Mapping the sub-structure of a pool.***
5. ***For accurate correlation in thick, uniform shale bodies.***
6. ***Locating the structural position of faults.***
7. ***Obtaining accurate logs through multiple strings of casing.***

Lane-Wells Radioactivity Well Logging Service is an advanced method of determining bore hole formation characteristics in both cased and uncased holes. Formations are reliably logged through as many as three strings of cemented casing. Results are not influenced by the fluid contents of the borehole.

Radioactivity Well Logging is based on the fact that all formations contain various amounts of radioactive material and that this radioactive material throws off rays which will penetrate many inches of steel and cement. The log is a curve similar in appearance to the "natural potential curve" recorded by Lane-Wells Electrolog in open hole.

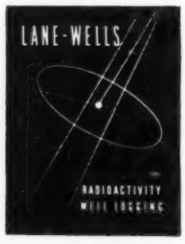
By knowing the relative Radioactive values of various formations, it is an easy matter to correlate or interpret the values logged as shales, sandstones and limestones on the finished curve.

The log denotes changes in lithology, or the "tops and bottoms" of all the formations present in the well. Shales contain considerable radioactive material, therefore, they show greater values than do sandstones or limestones, which contain much less radioactive material.

The instrument does not indicate fluid content. It does not give a direct indication of the relative porosity of the various sands and limestones found in a well, although, the presence of shale as an impurity in sandstones or limestones may be detected by its high radioactivity.

To the owners and operators of wells which were completed without Electrical Open Hole Logging, Lane-Wells Radioactivity Well Logging makes available the most complete information on formation characteristics possible to obtain. Errors which resulted from "hurry up" drilling practices can be detected. Productive sands cased off on the way down can be accurately located and opened for production.

Operators who have used this new service can tell you that Radioactivity Well Logging is an important Lane-Wells Technical Oil Field Service designed to get more oil at lower production costs.



SEND FOR THIS BULLETIN

The complete story of Radioactivity Well Logging is available... Write Lane-Wells, Los Angeles.

LANE-WELLS *Everywhere*

IN THIS EMERGENCY

Paraphrasing an old operatic lyric—"A steelman's lot is not a happy one." When business is at low ebb, the struggle is to get enough tonnage to produce steel economically. When the tide of business swings to the other extreme, the big job we all have is to satisfy the customer who is unable to get all the steel he needs.

Believe me when I say that this is one time when the wheel that squeaks the loudest is not getting the grease. We are doing everything humanly possible to be helpful in this emergency and to be fair in the apportioning of our output—and to assist you further we are constantly setting new records in all our plants in our production of ***steel—first line of national defense.***

R. J. Wysor
PRESIDENT

REPUBLIC *electric weld casing*

"Every joint stabbed and ran perfectly—the easiest pipe to run I ever handled," said an Illinois driller* after running his first string of Republic Electric Weld Casing—2960 feet of 5½-inch, 14-pound, Grade H-40, in two hours, thirty-five minutes. The next day he ordered a string for another well. • The straightness, roundness, uniform wall thickness, full clean threads, sound weld and normalized structure of Republic Electric Weld Casing will insure your satisfaction, too.

Descriptive literature giving recommended setting depths for the various grades will be sent on request.

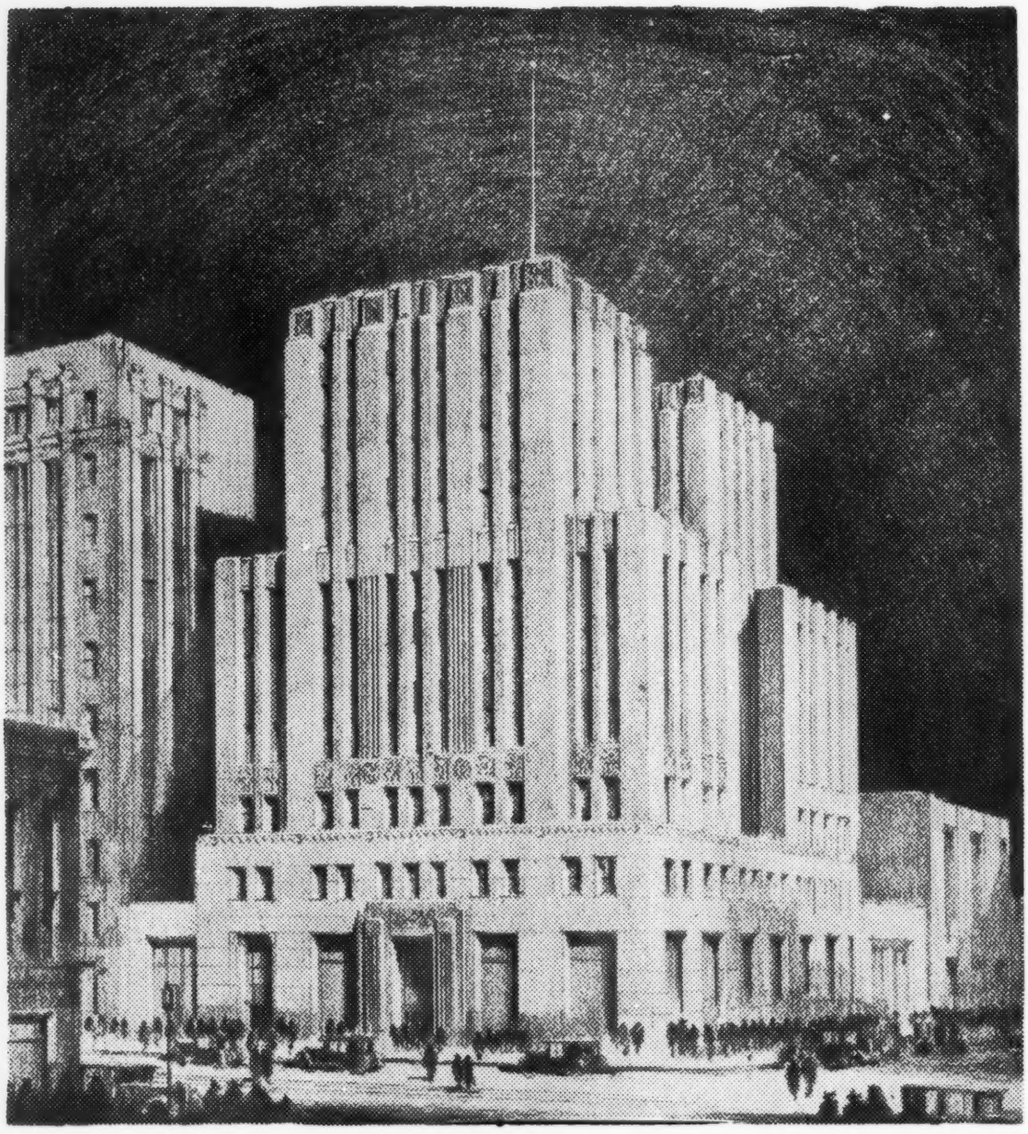
REPUBLIC STEEL CORPORATION

Howard Supply Company, Los Angeles, California • General Offices: Cleveland, O. • Republic Supply Company, Houston, Texas

BERGER MANUFACTURING DIVISION • CULVERT DIVISION
NILES STEEL PRODUCTS DIVISION • STEEL AND TUBES DIVISION
UNION DRAWN STEEL DIVISION • TRUSCON STEEL COMPANY

*Name on request

LINE PIPE—NORMALIZED CASING AND TUBING



You are Welcome to Dallas!

● *Above is the Dallas Gas Building, an affiliated distributing company of the Lone Star System. Occupying part of it are some of the general offices of the Lone Star Gas Company.*

Delegates attending Gasoline Convention in Dallas will find a warm welcome from all sides. It is at such conventions that industrial or business groups through an interchange of ideas and discussions are enabled to improve their product, service or production methods. We in the natural gas business have many problems of a nature similar to yours. In solving them we are guided by a simply stated general policy. It is: "First—find out what is the right thing to do. Then—what is the right way to do it." Your convention reminds us of this policy, for at its sessions one may learn "the right thing to do in the gasoline business and the right way to do it."

LONE STAR GAS COMPANY

PRODUCING AND DISTRIBUTING NATURAL GAS FOR FACTORY, BUSINESS AND THE HOME

OIL COUNTRY
YOUNGSTOWN
TUBULAR GOODS
EFFICIENT drilling equipment alone does not provide a fast, straight hole. The skilled men who operate it are the answer. In the same way Youngstown realizes the importance of the men who make Youngstown Tubular Goods. The dependable service Youngstown pipe delivers is due to the skill, long experience and pride of craftsmanship of Youngstown men. They are working for you--and they never forget it.
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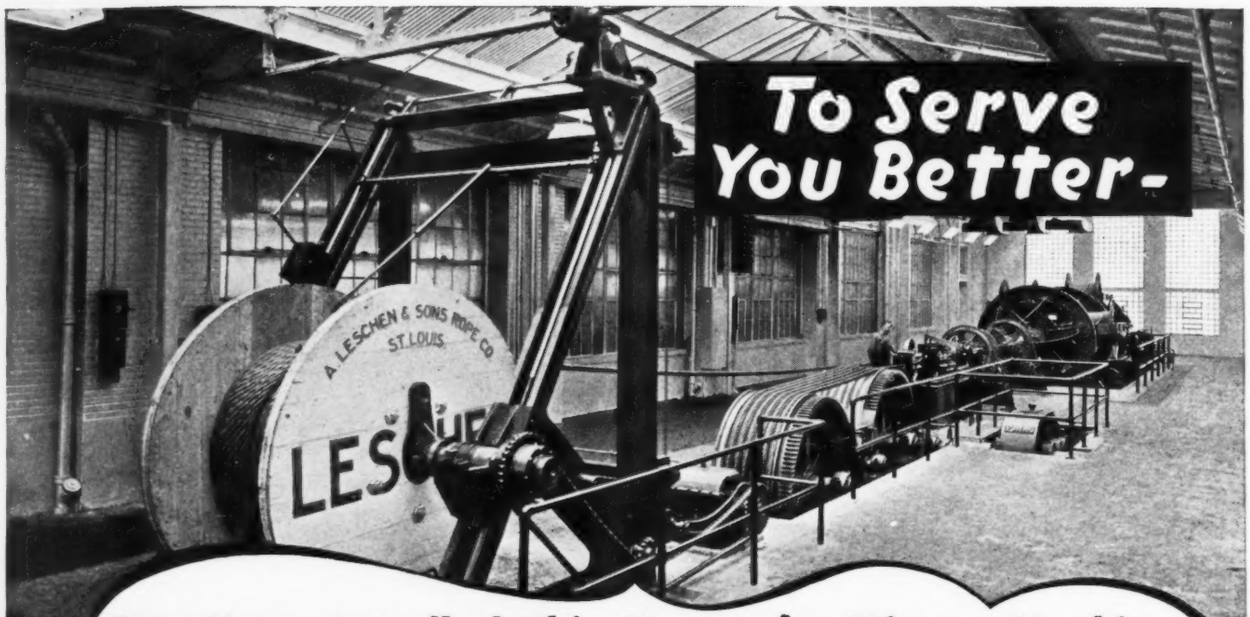
Youngstown's pipe is distributed by:
The Continental Supply Co. - - - - Dallas, Texas
Continental Emsco Co., Inc.,
30 Rockefeller Plaza, New York City
The Youngstown Steel Products Co.,
610 Petroleum Bldg., Los Angeles, California
★
Ask your distributor for Youngstown Pipe and Tubular Products - Sheets - Plates - Conduit - Tin Plate - Bars - Rods - Wire - Nails - Tie Plates and Spikes
2-28C
THE
Manufacturers of Carbon and Alloy Steels
General Offices - YOUNGSTOWN, OHIO



We Have Installed This Up-to-the-Minute Machine for Making "HERCULES" (Red Strand) WIRE ROPE

Reg. U. S. Pat. Off.

WHILE all wire rope making equipment in our plant is constantly kept at top efficiency . . . while new machines are added from time to time . . . while improved methods are continually being developed, we have installed this giant wire rope "closer" in order to serve you better at this critical time when the words "Quality" and "Service" take on added importance.

This new machine is the result — the culmination — of diligent research and long practical experience in designing, building and operating wire rope making machinery to meet definite and predetermined requirements . . . machinery capable of performing specific operations accurately and efficiently. Its design is such that, automatically, there is precise control of every stage in the closing operation. It is another Leschen example of where nothing is left to chance . . . Our endeavor to serve you better is in keeping with one of the fundamental policies that "Leschen Quality" and "Leschen Service" must continually move forward. In the ever advancing march of progress there is no place to stop and rest upon past accomplishments or past laurels. Because of our strict adherence to this policy, you can always depend on "HERCULES" (Red-Strand) Wire Rope for top-flight performance.

Domestic Distributors

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Charleston, W. Virginia
UNITED SUPPLY & MFG. CO.
Tulsa, Oklahoma City, Stonewall, Chase, Kans.; Hutchinson, Kans.; Eunice, N. M.; Denver City, Texas; Edna, Texas; Houston, Texas; Sundown, Texas; Odessa, Texas; Pampa, Texas.
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100,000-BBL. HORTONSPHEROID

Simplifies NATURAL GASOLINE BLENDING

at the HOUSTON TERMINAL of WARREN PETROLEUM CORPORATION

THE 100,000-bbl. welded steel Hortonspheroid illustrated above is being utilized to store natural gasoline at the Norsworthy, Houston, terminal of the Warren Petroleum Corporation. Complete facilities for thorough, efficient blending are incorporated in this spheroid. Three pipe inlets are used, allowing the various grades of natural gasoline to be run into the tank at three different levels. The end of each line in the tank is equipped with a jet arrangement which causes complete blending of the contents in the tank with that being pumped in. In addition, the spheroid is equipped with a blending spider located in the bottom of the tank through which liquids can be pumped and blended.

This is another example of the way in which Hortonspheroids are solving pressure storage problems throughout the oil industry. Spheroids are built in capacities up to 30,000-bbls. for withstanding internal pressures up to 30 lbs. per sq. in., and in larger sizes for pressures of from 2½ to 20 lbs. per sq. in. Where higher pressures are desired, the Hortonsphere is recommended. For complete information on Horton pressure storage units, please call or write our nearest office.

CHICAGO BRIDGE & IRON COMPANY

Fabricating Plants in BIRMINGHAM, CHICAGO and GREENVILLE, PA.

DALLAS.....1671 Praetorian Bldg.
HOUSTON.....918 Richmond Avenue
TULSA.....1634 Hunt Bldg.
BIRMINGHAM.....1570 N. 50th Street
CHICAGO.....2481 McCormick Bldg.
DETROIT.....1538 Lafayette Bldg.
CLEVELAND...2251 Builder's Exchange
PHILADELPHIA....1635-1700 Walnut St.
NEW YORK....3373-165 Broadway Bldg.
BOSTON...1535 Consolidated Gas Bldg.
SAN FRANCISCO.....1064 Rialto Bldg.
LOS ANGELES.....1446 Wm. Fox Bldg.

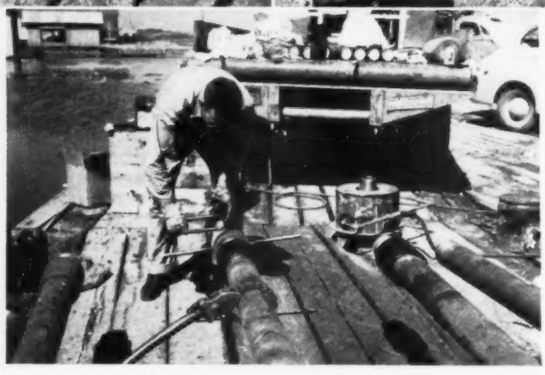
LICENSEES: Horton Steel Works, Limited, Fort Erie, Ontario, Canada; The Motherwell Bridge & Engineering Co., Ltd., Motherwell, Scotland; The Whessoe Foundry & Engineering Co., Ltd., London, England; Worms & Cie, Paris, France; Compagnia Tecnica Industrie Petroli, S.A.I. Rome, Italy.

HERE IS ONE ITEM YOU CAN MARK OFF YOUR BUDGET FOR '41

THE REED SUPER SHRINK GRIP TOOL JOINT IS EASILY REPLACED "AT THE RIG"

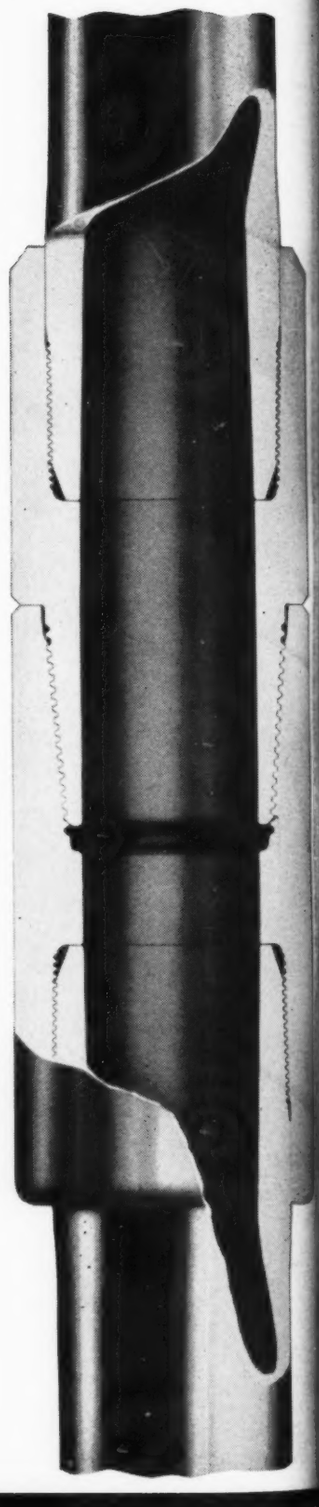
Reed Super Shrink-Grip Tool Joints answer every possible demand of the industry for uniformity, dependability, longer life, safety and lower replacement costs. This new tool joint incorporates all of the advantages of the Reed regular Shrink-Grip Tool Joint, plus the added advantage of replacement "at the rig"—by simply heating and screwing on by hand.

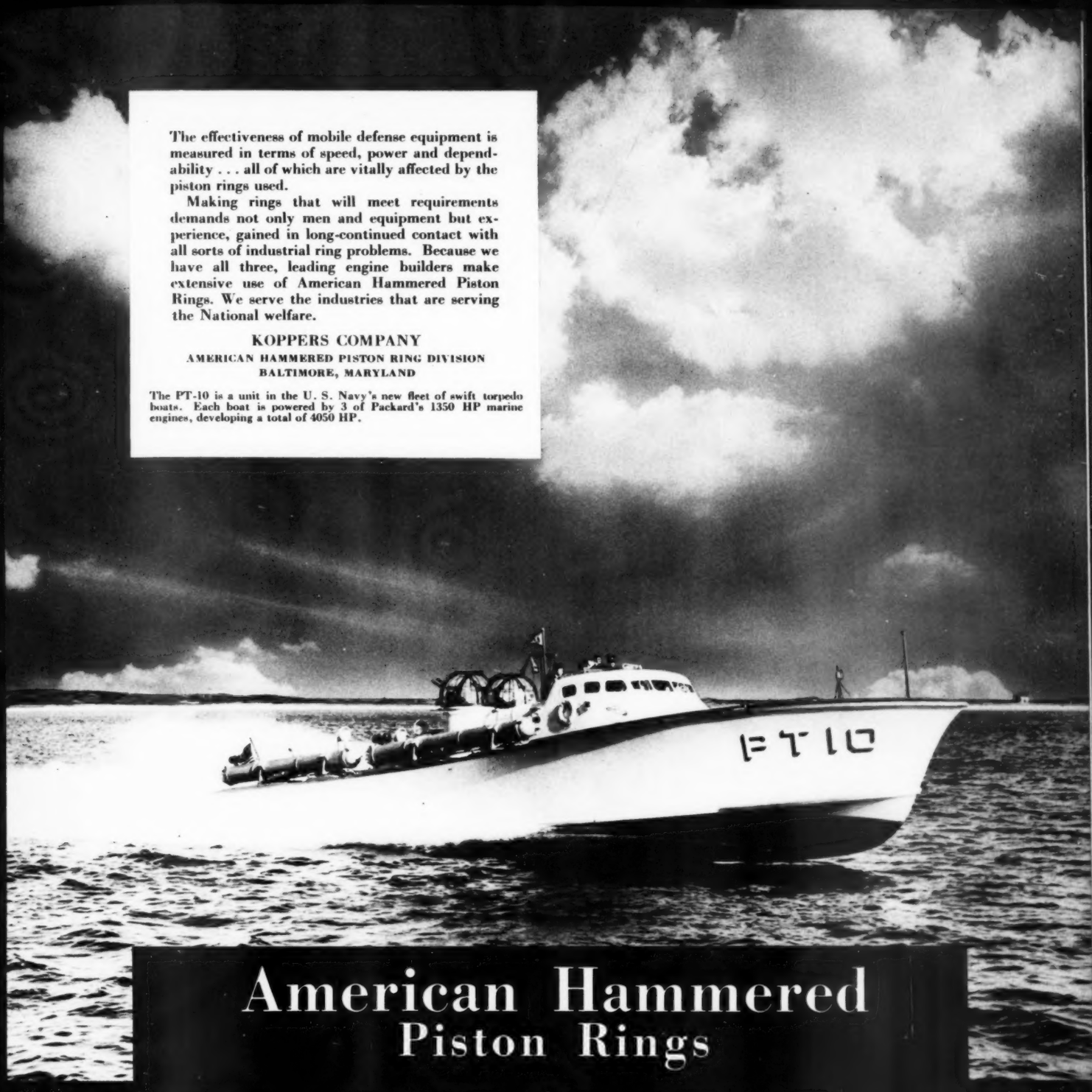
The start of the cutting-off operation with the acetylene torch. Care is exercised so that the threads or land on the pipe are not injured.



By means of the brace type wrench, the heated tool joint is quickly screwed onto the drill pipe by hand, until the shoulder within the tool joint seats on the end of the drill pipe. Cooling causes the tool joint to shrink onto the drill pipe and the pipe is then ready for drilling service.

After removal of the old tool joint, clean, good-as-new threads and sealing land are in evidence, and ready to receive a new tool joint.





The effectiveness of mobile defense equipment is measured in terms of speed, power and dependability . . . all of which are vitally affected by the piston rings used.

Making rings that will meet requirements demands not only men and equipment but experience, gained in long-continued contact with all sorts of industrial ring problems. Because we have all three, leading engine builders make extensive use of American Hammered Piston Rings. We serve the industries that are serving the National welfare.

KOPPERS COMPANY
AMERICAN HAMMERED PISTON RING DIVISION
BALTIMORE, MARYLAND

The PT-10 is a unit in the U. S. Navy's new fleet of swift torpedo boats. Each boat is powered by 3 of Packard's 1350 HP marine engines, developing a total of 4050 HP.

American Hammered Piston Rings

a KOPPERS product

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KOPPERS COMPANY
7110 Koppers Building
Pittsburgh, Pa.

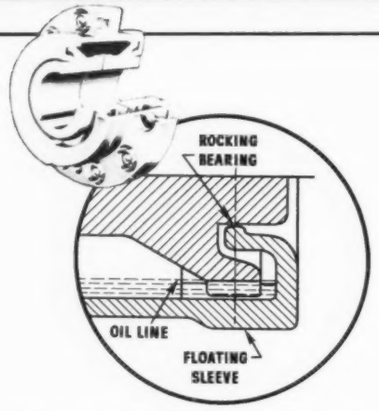
"Bill, tell me why you insist on FAST'S COUPLINGS for this new equipment"

"Because," says the maintenance engineer, "you're holding me responsible for keeping it in continuous operation . . . and I want a coupling I can depend on." He *knows* that he'll get it . . . with "Fast's."

Dependability is *designed-into* and *built-into* Fast's Couplings. The load-carrying surfaces are protected against wear by a positive film of oil. This oil is kept permanently clean by the rocking bearings which make precise metal-to-metal contact, and are in the *one position* where they form permanent dust and moisture-proof seals.

Continuous operation is of extra importance today. Prevent operating troubles by specifying *genuine* Fast's Couplings on the machinery you purchase.

KOPPERS COMPANY
BARTLETT HAYWARD DIVISION
BALTIMORE, MARYLAND



This detail drawing and "cut-away" view show Fast's construction. Note that no perishable materials are required to make it dust and moisture proof. This vital feature is found *only* in *genuine* Fast's Couplings.

a KOPPERS product

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Please send me the technical information checked:

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- ☐ "Phenolate Gas-Purification Process for Removal and Recovery of Hydrogen Sulfide"
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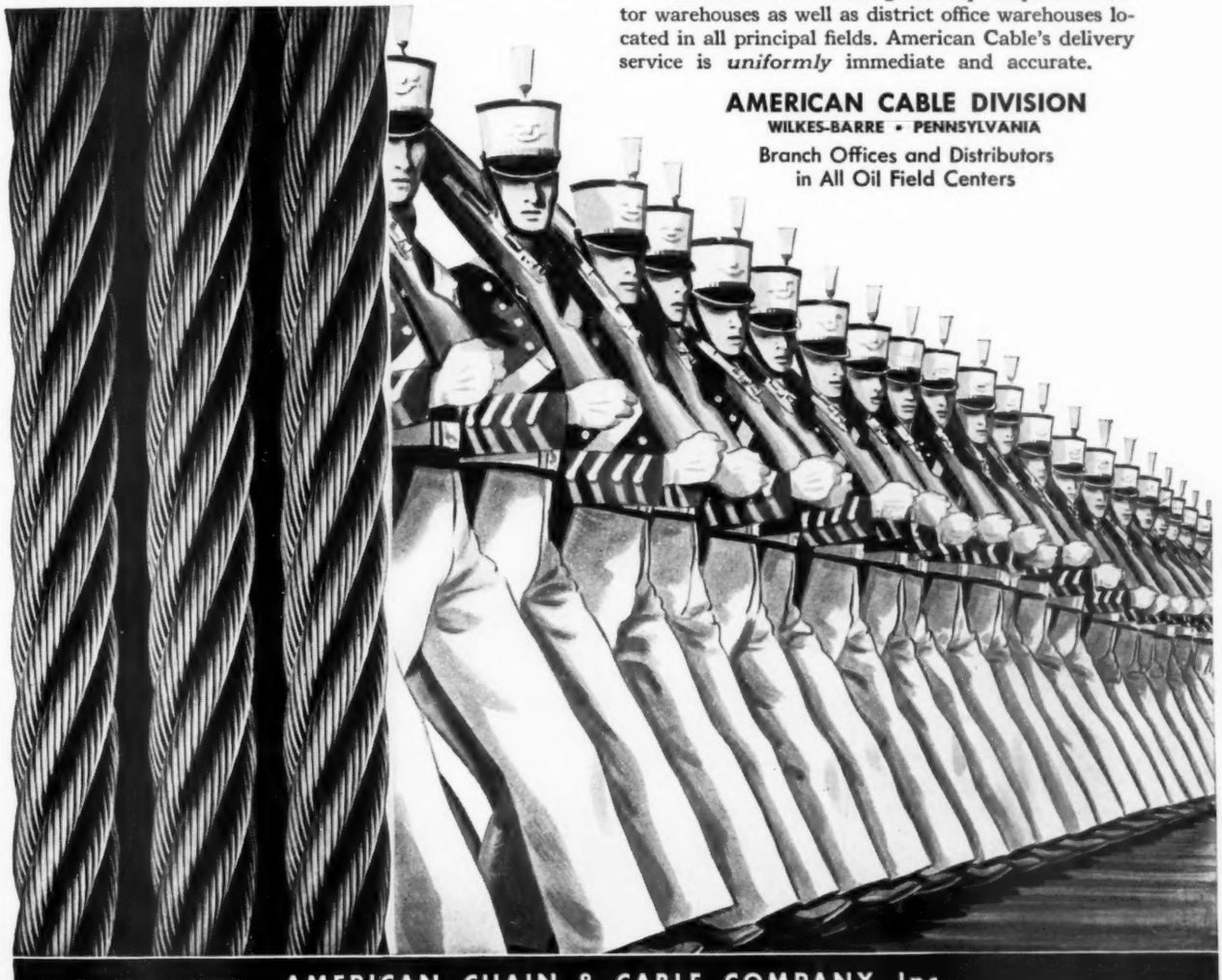
Fill out and mail

AMERICAN CABLE
CRESCENT CABLE TOOL LINES
Are Uniform

UNIFORM IN QUALITY This is a universally acknowledged characteristic of American Cable wire lines—by cable tool drillers everywhere.

UNIFORM IN SERVICE Being uniform in quality, American Cable's CRESCENT lines are naturally uniform in service. Literally thousands of cable tool drillers have found CRESCENT so uniformly high in enduring quality, well after well, that today—solely by word-of-mouth advice hundreds of other drillers are depending upon CRESCENT exclusively. *All* have long since learned that reel after reel of CRESCENT Non-Preformed lines are absolutely uniform in both metal and manufacturing quality. American Cable CRESCENT lines have *drillability*.

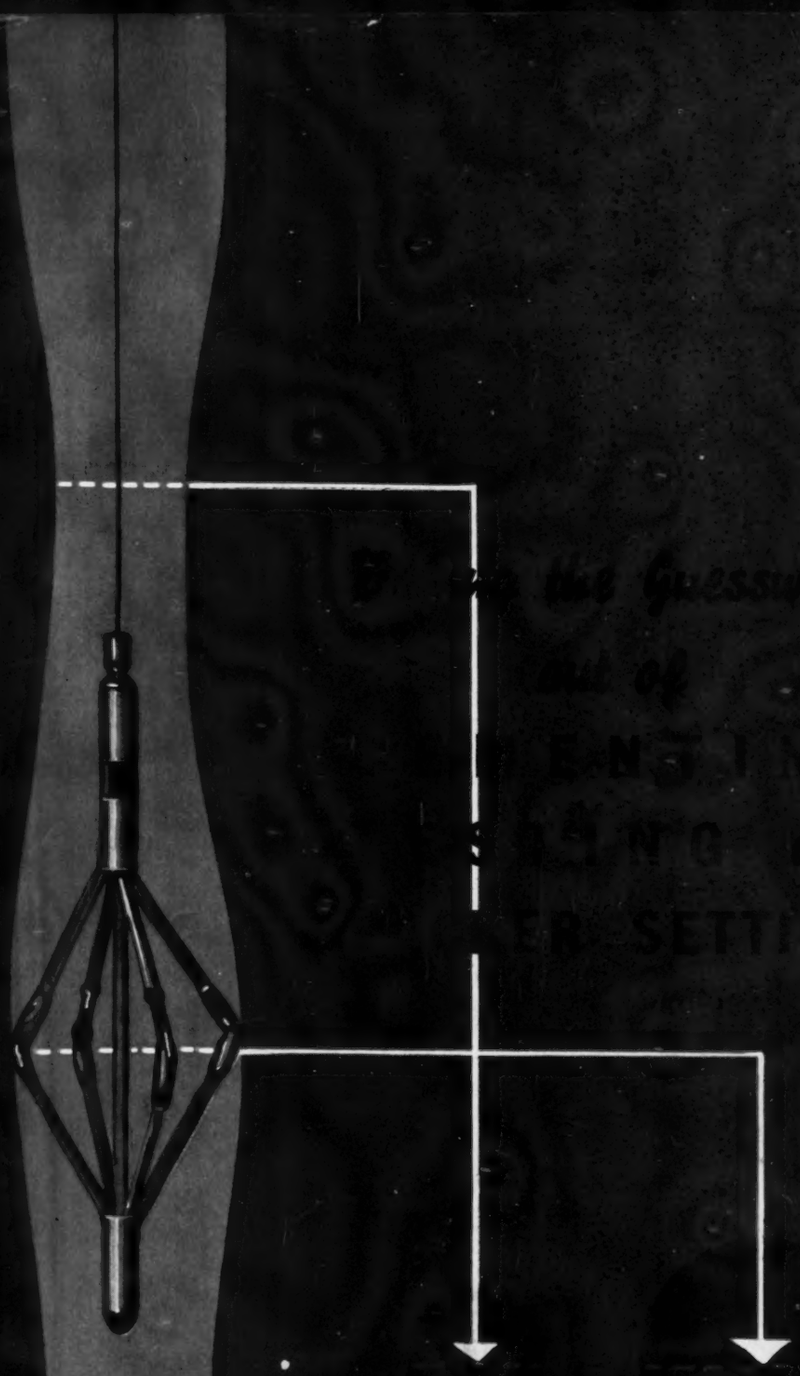
UNIFORM IN DISTRIBUTION The American Cable Division maintains large stocks of all kinds of wire drilling lines in principal distributor warehouses as well as district office warehouses located in all principal fields. American Cable's delivery service is *uniformly* immediate and accurate.



AMERICAN CABLE DIVISION
WILKES-BARRE • PENNSYLVANIA
Branch Offices and Distributors
in All Oil Field Centers

AMERICAN CHAIN & CABLE COMPANY, Inc.

ESSENTIAL PRODUCTS . . . AMERICAN CABLE Wire Rope, TRU-STOP Emergency Brakes, TRU-LAY Control Cables, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Iron Castings, CAMPBELL Cutting Machines, FORD Hoists and Trolleys, HAZARD Wire Rope, Yacht Rigging, Aircraft Control Cables, MANLEY Auto Service Equipment, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Electric Steel Castings, WRIGHT Hoists, Cranes, Presses . . . *In Business for Your Safety*



HOWCO CALIPER SERVICE

By progressively measuring the actual variation in the diameter of open hole in a well, the calipers provide data for accurate volumetric calculations of the portion of the hole to be cemented. This important data is also useful in making studies of drilling conditions, for packer settings, for determining the points of entry of acid, for studying the effect of nitroglycerin shots, etc., etc. These calipers are the result of a joint program between Myron Kinley, who pioneered the caliper field, and Halliburton, and are now ready for daily use.

HALLIBURTON OIL WELL CEMENTING COMPANY

Tretonite

LOW COST PROTECTION AGAINST VAPOR LOSS For EXISTING STORAGE TANKS

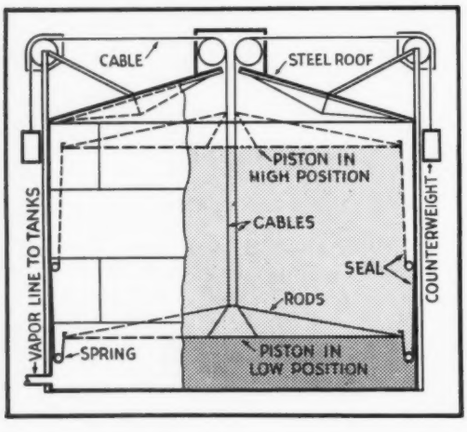
EVAPORATION losses from a group of existing fixed-roof storage tanks handling volatile products can be reduced by installing a Wiggins "piston-type" Balloon, and connecting it to the vapor spaces of the tanks through large diameter, light gauge piping. This system makes use of the simple fact that no loss can occur as long as vapor is not permitted to escape. To secure maximum savings, installations should be provided with a balloon having sufficient capacity to eliminate all venting under normal operating conditions.

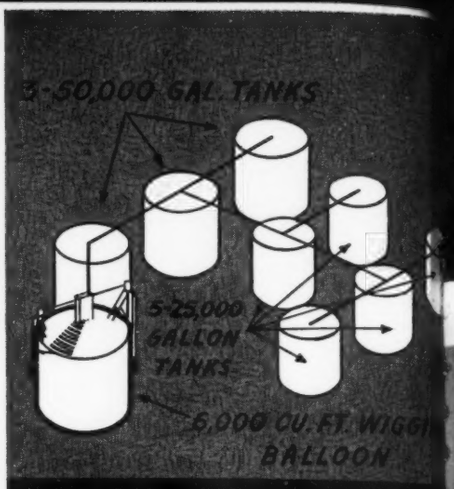
Breathing Losses Prevented

When the temperature rises during the day, evaporation occurs in the tanks at the liquid surface, and the air-vapor mixture above the surface expands, the excess flowing through the vapor lines to the balloon. At night, when the temperature falls, vapor is reabsorbed at the liquid surface, and the contents of the balloon return to the tanks. This daily return of vapor prevents the breathing loss which would otherwise occur.

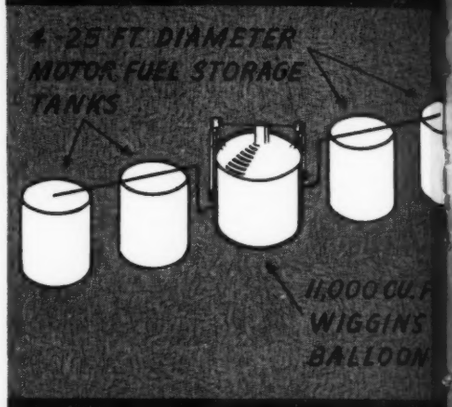
The Wiggins "piston-type" Balloon is primarily recommended for installations where a maximum of 50,000 cu. ft. capacity is required, and it is particularly applicable for service at bulk marketing stations. For complete information, please call or write our nearest office.

• The Wiggins "piston-type" Balloon consists of a counter-weighted circular deck or piston which moves up and down inside a cylindrical steel shell. (See sectional view below.) The piston descends to the bottom when the balloon is empty and rises as the balloon fills with vapor. The seal used is a special gas-tight fabric, tubular in shape. One end is attached to the inside of the shell of the balloon while the other is attached to the rim of the piston. Very slight pressure is sufficient to move the piston.

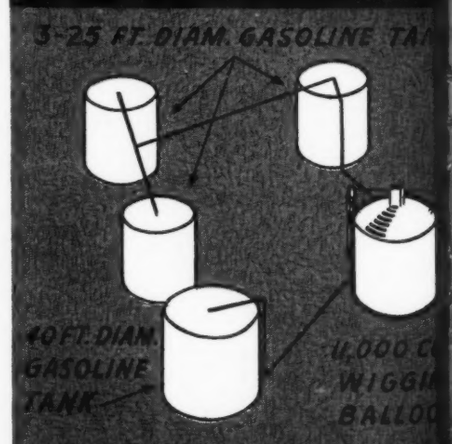




• This installation consists of eig tanks with a total capacity of 275,00 gals., connected to a 6,000 cu. capacity Wiggins Balloon. In tw year's time, figures show that a tot of 21,400 gallons of gasoline we saved—more than enough to pay t the installation!



• The vapor spaces of four 25 diam. motor fuel tanks are connec to a 11,000 cu. ft. Wiggins Balloon this marketing station. In ove year's operation, all venting dur standing storage has been stopp and filling losses have been redu materially.



• This gasoline bulk plant installa consists of three 25 ft. diam. and 40 ft. diam. cone roof tanks, conne into a Wiggins "piston-type" Ball which has a capacity of 11,000 c — sufficient to handle the vapor all four tanks.

CHICAGO BRIDGE & IRON COMPANY

DALLAS	1671 Praetorian Bldg.	CLEVELAND	2251 Builder's Exchange
HOUSTON	5621 Clinton Drive	PHILADELPHIA	1635-1700 Walnut St.
TULSA	1634 Hunt Bldg.	NEW YORK	3373-165 Broadway Bldg.
BIRMINGHAM	1570 N. 50th Street	BOSTON	1535 Consolidated Gas Bldg.
CHICAGO	2481 McCormick Bldg.	SAN FRANCISCO	1064 Rialto Bldg.
DETROIT	1538 Lafayette Bldg.	LOS ANGELES	1446 Wm. Fox Bldg.

Fabricating Plants in BIRMINGHAM, CHICAGO, and GREENVILLE, PA.
In Canada HORTON STEEL WORKS, LIMITED, FORT ERIE, ONTARIO

WHAT A FIVE-SPEED, EVEN-RATIO TRANSMISSION MEANS TO YOU

WHEN OPERATING A DRILLING RIG OR SERVICING HOIST

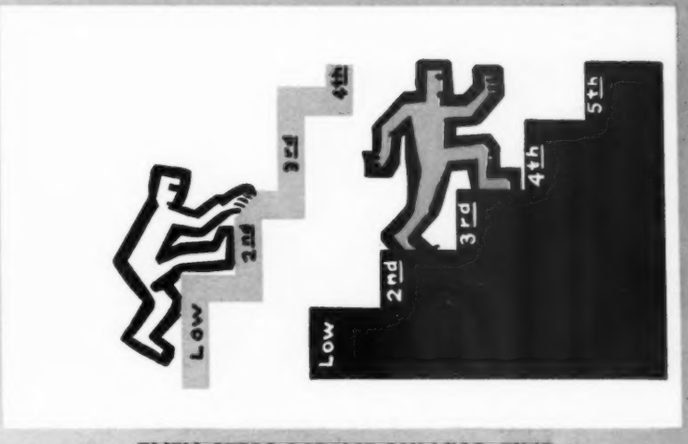
EVEN-RATIO GEAR CHANGES SAVE TIME

You can save valuable time coming out of the hole with drill pipe, tubing or casing, when your rig is equipped with a "Cardwell" five-speed, even-ratio transmission. The even-ratio gear changes permit quicker step-up to a faster gear as the load lightens. It is possible to shift into second and third while the ordinary four-speed, truck-type transmission is "lugging" in low.

RESULTS — faster operation with less fuel and fewer "burned-up" engines.

When running the drill pipe or tubing back into the hole, a single lever shift into low enables the load to be quickly picked up off the slips for lowering in. Another quick, single lever shift from low to high "runs-up" the empty block after setting the slips.

RESULT — more time saved.

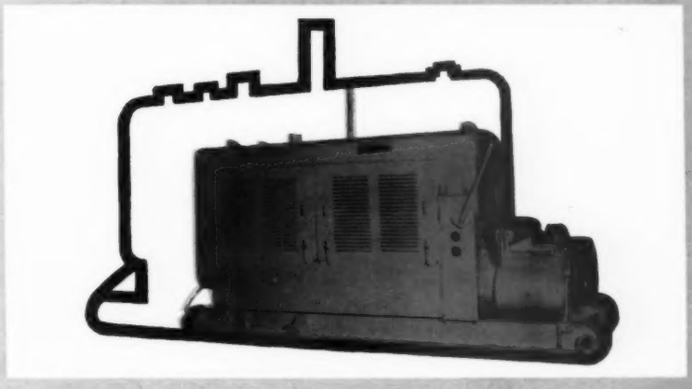


EVEN STEPS REDUCE PULLING TIME

SMALL ENGINE GIVES THE SAME SPEED AS A LARGER ENGINE

A 250 HP engine equipped with a "Cardwell" five-speed, even-ratio transmission will give the same operating speed as a 300 HP engine equipped with the usual transmission arrangement.

RESULTS — the smaller engine saves on first cost, maintenance expense and transportation costs.



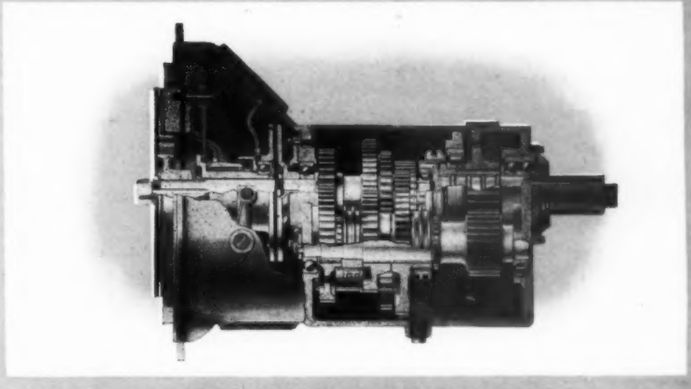
YOUR OPERATING SPEED IS AUTOMATICALLY 20% FASTER

THE VALUE OF A CONSTANT GEAR MESH TRANSMISSION

How much has transmission breakage cost you during the past two years? A major oil company operating in West Texas reports no repairs or trouble of any kind with the "Cardwell" five-speed, even-ratio transmission mounted on their "Cardwell" spudder rig, after two years constant operation.

This transmission is designed so that all gears are in constant mesh and are selected by sliding gear tooth collars, eliminating the partial gear tooth engagement that causes so many breakdowns. Stub tooth spur gears are used to give heavy load-carrying and shock-resisting capacities.

RESULTS — the hazard of a lost string of tools, stuck drill pipe or a fishing job due to transmission breakage is greatly reduced.



1,400 FOOT-POUND TORQUE CAPACITY

Only "Cardwell" builds a five-speed and reverse, even-ratio gear type transmission with a torque capacity of 1,400 foot-pounds at 1,000 RPM, or the equivalent of 265 HP.

CARDWELL ALL STEEL

THIS TRADE MARK INSURES HIGHEST QUALITY AT LOWEST PRICE

CARDWELL MFG. CO. INC.

FORMERLY ALLSTEEL PRODUCTS MFG. CO.

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